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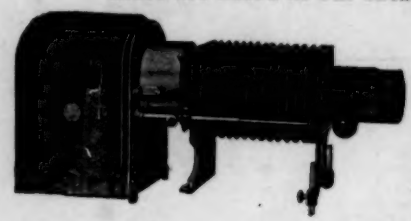

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SCHOOL SCIENCE AND MATHEMATICS

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SOME GROUP THEORY.

BY G. A. MILLER,

University of Illinois, Urbana.

In their report entitled "Training of Teachers of Elementary and Secondary Mathematics" a subcommittee of the International Commission on the Teaching of Mathematics named the following nine subjects as those which may later be expected to be involved in the preparation in pure mathematics of the prospective mathematics teacher: Calculus, differential equations, solid analytic geometry, projective geometry, theory of equations, theory of functions, theory of curves and surfaces, theory of numbers, and some group theory. The natural significance of the adjective *some* in connection with the last of these nine subjects would seem to be that the knowledge of the prospective teacher along the line of group theory need not be as thorough as that along the other lines named, but that he should know something about this subject.

It is evident that strictly speaking, the adjective *some* should have modified each of the other subjects named above, since no one can know *all* about any one of the broad fields covered by them, but the common usage of these terms seems to justify the conclusion that what is meant is that the prospective teacher should have a good course, or its equivalent, in each of these broad fields of pure mathematics, except possibly the last one. In regard to this field it might be sufficient if he had listened to a course of lectures devoted to it or had looked over some of the literature relating thereto.

Two questions naturally present themselves in this connection. The first of these is, Why should the teachers of elementary and secondary mathematics be expected to know anything about group theory? If good reasons exist for demanding such a knowledge, it is natural to ask, Why is a superficial knowledge in this field less objectionable than in the other fields noted above?

The former of these questions could scarcely embarrass anyone who possesses at least a slight knowledge of the modern literature on elementary and secondary mathematics. When one reads that such fundamental notions of geometry as point, line, and plane can be based upon group notions, and "that the idea of displacement, and consequently the idea of group, has played a preponderant part in the genesis of geometry"[1] one can easily see why teachers of elementary geometry should know *some* group theory.

The teachers of elementary arithmetic and elementary algebra may have less conscious need of a knowledge of group theory than those of elementary geometry, but the former are likely to read about the groups and subgroups formed by certain sets of real or complex numbers with respect to multiplication, and the groups and subgroups formed by other sets of such numbers with respect to addition. Moreover, the group properties of the n roots of unity may easily present themselves to such teachers as soon as they think just a little beyond what they are actually expected to teach.

Having established the fact that the teachers of elementary and secondary mathematics must know something about group theory in order to understand some of the best modern literature relating to the subjects which they are expected to teach, it remains to answer the second of the two questions raised above. Since there is an algebraic group theory, an analysis group theory and a geometry group theory, one might perhaps infer that the use of the adjective *some* in the list of subjects mentioned in the first paragraph of this article might have been due to a feeling that the subject of group theory was too broad to come within the mathematical purview of the prospective teacher, and that such a student should therefore confine his attention either to a special part of this subject or to a somewhat superficial survey of the whole field.

It is, however, less interesting to consider the possible reasons for the use of the adjective *some* in the given connection than to inquire what elements of group theory are of most importance to the prospective mathematics teacher. It might be supposed that these elements should include only one definition of the word group as a technical mathematical term. Since various writers use this term with different meanings, the reader who has only a single definition in mind is likely to be embarrassed there-

[1] H. Poincare, *The Monist*, vol. 9 (1899), p. 32.

by and hence one definition of this term, may be worse than none. Perhaps the most important idea for the student to acquire early in regard to group theory is that *there is not only one definition of the mathematical term group* but there are several, and there is not only one group theory but there are several such theories.

How then can we know that a certain set of operators constitutes a group? With respect to a finite set there is little trouble, since all the definitions of finite discontinuous groups which are found in good modern literature are practically equivalent. This is, however, not the case as regards the definitions (explicit or implied) of an infinite group. In fact, such a standard work as the *Encyklopädie der Mathematischen Wissenschaften* contains on page 218 of Volume I a definition which is satisfied by the infinite set of numbers of the form.

$$\frac{2^q}{q} \text{ being any natural number,}$$

when these numbers are combined by multiplication. It is evident that this set of operators does not involve the identity, since 0 is not a natural number, nor does it involve the inverse of any of its operators.[2] If we would let q assume also the value 0, the set would include the identity but not the inverse of any of its other operators.

The most comprehensive definition of the technical term group is found on page 243 of tome I, volume 2, of the *Encyclopédie des Sciences Mathématiques*.[3] It is as follows: "One says of an aggregate of objects that it forms a group in the most general sense of the word, when there is given a rule permitting to deduce from any two A and B of the objects of the aggregate a third object C of this same aggregate." It is evident that this definition of group does not imply the existence of an identity or of the inverse of an operator in the aggregate under consideration. In fact, the aggregate may contain various identities and various inverses of the same operator and still satisfy this definition of a group as results directly from the consideration of algebraic number fields, which are included under the term group in both the German and the French editions of the large mathematical encyclopedia.

One frequently finds in recent mathematical literature criticisms relating to the use of the term group with respect to a

[2] A. Loewy, *Archiv der Mathematik und Physik*, vol. 9 (1905), p. 105.
[3] A similar definition appears in tome 3, volume 1, page 334, of this work.

set of operators which are said not to form a group by the authors of these criticisms. For instance, A. Loewy criticizes, in the article to which we referred, the definition of the term group as given in the large German mathematical encyclopedia, stating that it is necessary to add another condition in order to obtain a definition of an infinite group. On the other hand, the conditions imposed in the said encyclopedia definition are already much more restrictive than those imposed in the definition cited in the preceding paragraph and they include the latter. Hence it is clear that this particular criticism by an eminent authority is based on the assumption that such a definition as the one cited in the preceding paragraph is too general.

We refer to this matter in order to emphasize the fact that what appeared to many as an illegitimate use of the term group due to carelessness or ignorance has been legalized in recent years. The technical term group has thus been given a breadth of meaning comparable to that given to the term function in 1837 by a definition due to Dirichlet. This breadth of meaning is, however, not new but it embodies the fundamental notion which guided the earliest investigators in this field and to which certain explicit restrictions were added by later writers with a view to definite progress in certain directions.

Such restrictions remain desirable and will doubtless be continued, but instead of saying they are imposed on *all* groups we should say that they are imposed on the particular groups under consideration. Thus there arises the desirability of further classification of groups, and the study of groups in which the inverses of the operators are not present or in which a linear equation may have more than one solution. Up to the present it has been customary to study only those groups in which the inverse of each operator is present and in which a linear equation has only one solution. On the other hand, an equation of higher than the first degree can have more group elements for roots than the degree of this equation. These groups have been divided into four great classes named as follows: Finite, infinite discontinuous, finite continuous and infinite continuous.

The most important property of groups is the existence of *subgroups*, and hence subgroups should be considered immediately after some of the definitions of groups have been examined and illustrated. In particular, the facts that the order of a subgroup divides the order of the group whenever this order is finite, and that an invariant subgroup corresponds to the identity

of an isomorphic quotient group are of fundamental importance and should be included in the briefest course along this line. The subgroups of the continuous groups of movements of space corresponding to points and to lines respectively, are also of fundamental importance.

An important notion which is intimately connected with group theory but which is not confined to this subject is that of *isomorphism*. The special isomorphism in which there is a (1,1) correspondence between the elements of two groups is particularly important since it enables us to study once for all the fundamental properties of large categories of groups, and since it gave rise to the notion of abstract groups. Moreover, the possible isomorphisms of a group with itself are of fundamental importance in some of the applications of these groups. Hence the question of isomorphisms might well be considered immediately after that of subgroups, even if a thorough study of this question cannot be taken up until after a considerable body of theorems relating to group properties has been established.

The most important continuous group is composed of the transformations under which the properties of figures studied in elementary geometry are invariant. This group consists of movements, reflections, and similarity transformations and was called by F. Klein the *principal* or *fundamental group*. Two of its most important subgroups were noted above. It is interesting to note, in particular, that the dimensions of space are invariant under this group. As an instance of a group, in the most general sense, under whose transformations the dimensions of space are not invariant we may refer to the following:

$$x' = ax+by$$
$$y' = akx+bky$$

which clearly transforms all points of the plane into those of a line passing through the origin, if we regard a and b as parameters and k as a constant.

The most important finite group is the cyclic group and there is one and only one such abstract group of each order. The cyclic group of order n is perhaps best known in the form of the n nth roots of unity. Among non-cyclic groups of finite order the dihedral groups, or groups of the regular polygons, are perhaps the most important. It must, however, be admitted that it is difficult to decide which are the most important among the hosts of finite and infinite groups intimately related with questions of elementary mathematics. Moreover, groups are social

entities and can be studied better in connection with their social environment than by isolation.

Enough may have been said to show that the suggestion that prospective teachers of elementary and secondary mathematics should know *some* group theory cannot reasonably be assumed to imply that this subject is less intimately related to their teaching than any of the other eight subjects named above. Nor should it be assumed that the study of this subject normally belongs at the end of the teacher's preparation in pure mathematics. In fact, *some* group theory should come early among the courses which follow a first course in calculus, and later studies in mathematics should be illuminated by the group concept. The main reason why students often find the study of group theory difficult is that it is usually taken up late in their course and then developed from a very abstract point of view.

Groups are intrinsically a part of our natural mathematical endowment and the group concept should be nurtured in our early mathematical development by directing attention to group properties appearing in elementary geometry and in elementary arithmetic. On the contrary, this concept is allowed to famish while other mathematical concepts are nurtured, and then when late in the student's course he turns back to it for light towards the solution of some of his most difficult problems, he naturally finds a weakling whose normal development would demand more time than he feels that he can then give to it. Total starvation is the natural consequence.

BLACK WALNUT WANTED.

The virtue of the black walnut has been its own undoing. Because it does not readily warp or split, it is the best of all woods for airplane propellers and gunstocks, and the Government finds that the demand greatly exceeds the supply. An appeal, therefore, is being made to all owners of walnut, to assist in getting every available log to market. County agents and boy scouts are being pressed into service for locating walnut trees, and everybody interested in winning the war is urged to report the existence of available material. The logs wanted are at least twelve inches in diameter at the small end and eight or more feet long. The Government does not buy this timber but will put owners in touch with manufacturers who are using it. The price at present is about $90 a thousand feet. A tree that will square twelve inches and make a log sixteen feet long is therefore worth nearly $20. We are frequently told that certain products are scarce because of the war, and this is likely to be true of walnuts for some time to come.—[*American Botanist.*

MR. DOOLEY, 2D, ON THE DISCUSSION METHOD

(With Apologies to the Original Mr. Dooley.)

By Jean Broadhurst,

Teachers College, Columbia University.

Ye' see, Michael, me b'y, since me faythe settled so manny questions av internashunal dispute, it cum to me natshral loike to be inthrusted in the prisint day and its problims. And me posishun av windy washin' at collige is furtherin' me in the way av it, for windy washin' is a quiet job and slow, as is well known. So I hear manny a thing that me puir faythe missed altogither. And the quarest av thim all is the way thim big perfessors is a tryin' to git shut av their jobs, entoirely.

Do ye iver hear me, Michael, a sayin' that the windys don't need washin' or cud wash thimsilves? Be gorrah, a man 'ud be two fules in wan, he wud, to do that—for he'd sure lose his job altogither and the windys wudn't be washed at all, at all.

But this discussin method is a quare one. As I kin make it out, it's a way the perfessors have av lettin' the scholars run on by thimsilves loike a horse widout anny driver at all. No, it's not loike Murphy it is, fur his old white horse stops at ivry house and waits till Murphy gives the baby his bit av pasteurized milk for the day, and comes out wid the empties. That's not loike the discussin way at all, for old Murphy knows where his horse is ivry minute and where he's goin', and what's more, the old horse fetches up at the *right* places ivry time. But in the discussin way, a horse ud av to av the wings av a bird and legs av a kangrue, for he'd av to jump from one street to anuther and skip whole blocks intoirely; and to kape up wid him Murphy wud av need av an aeroplane wid all the accelirators and patent brakes that av yit to be invinted. Besides, Murphy's horse niver goes backward, me b'y. He's a wise old horse, and *he'd* know it av he did.

Now, as I kin make it out, in the discussin way the perfessor starts 'em on a little way wid his highbrow stuff, and thin he drops the lines intoirely. And ivry horse pulls a different way, zigzaggin' around as if the royal road to learnin' was the Abbey Inn hill for the steepness av it.

And thin, whin thim as don't discuss, the passingers, so to speak, have been yanked this way and that till they don't know which way they're goin', sumthin' breaks, and the hull thing stops, wid each av thim discussers in a diffrunt place; and the passingers begin wanderin' about aimless-like, some av thim

evin goin' back where they started at the fut av the hill and not knowin' it at all, and thinkin' they're goin' ahead, bedad.

It's all true. They're befuddled as no whisky cud do it in so short a time evin in this prohibishun town. But the perfessor, ye say. Well, it depinds on the perfessor. There's nothin' harder to ketch than a horse broke loose, but some av thim perfessors kin do it. Some av thim let the discussers tire thimselves out, and some av thim ketches and houlds thim by feedin', a scatterin' the grain around. A handful av wheat goes a long way, if you mix it wid chaff, me b'y. But some av thim perfessors'll be caught by the pure food laws yit. There's only wan thing that's saved thim so far—that their stuff ain't done in packidges! There's no label to say what's chaff, but the adultration's somethin grand. It'd make anyone av thim rich, if it was gasoline or evin sugar he was by the way av dealin' in.

No, it's a quare way to me way av thinkin'. The perfessor starts 'em off a discussin' by telling 'em a little av what he knows, the straight stuff, and thin the discussers break in to tell about what they don't know about. They actually git up and say, "I've niver had any experience in this field, but some years ago, I"—would ye believe it! And often and often agin they say, "I am unable to offer anything in the direct line av this discussin," and thin talk for twinty minutes!

But I'm thinkin', some av the perfessors av caught onto the way to stop it. For some av thim begin, "This mornin' we will discuss the educashun av the child from the standpoint av—" ye can't expect me to remimber the rist av it—and thin talk *thimsilves* till the bell rings! They're the wise guys, they be, for *they* git sumthin' done. Thin iverbody's more satisfied, fur the classes thinks they've been discussin', which flatters the edicated mind, and they've learned sumthin', too, which ain't so common in the rale discussin way.

And the worst av it is it's a spilin' the schools, too. Me little Jimmie is a bein' learned the same way. The taycher starts out to learn thim that Connecticut raises tobaccy and the kids wid opporchunities or imaginashuns get up and say, "When I was to me grannie's in Maryland I seen fields and fields of tobaccy"; and "Me uncle owns two tobaccy farms in Kentucky"; and "When we go on our vacashun in our motor car, maybe we'll go to Connecticut and see thim tobaccy fields."

Why can't they "believe the painter" whin the taycher tells thim it grows in Connecticut widout all this introducshun? And

they discuss, too, just like the grown ups, wid the taycher leadin' thim on, wid "Why is Connecticut a tobacco state?" And they guess all the raysons they can think of—the ones they had for corn and watches and firearms and shoes till somebody strikes the one the taycher knows about. And thin they start over agin a keepin' the smart Alecky ones a talkin' all the time; and the kids don't hear no good grammar day in an' out wid the glib ones a gettin' glibber and the slow ones overworked sortin' out which is talk and which is learnin'.

And all this discussin' and spreadin' thimsilves out thin spoils thim fur rale work, I'm thinkin'. There's some classes in collige the discussers niver take—or if they do, they drop it afore the day av reckonin', the examinashun, so to speak.

Why, there was wan wuman discusser—there's comparative few faymale discussers, but some av thim's as bad as the men—who got into a reg'lar class 'stead av a discussin one. She'd been fed up on discussin where it's "all a matter av opinion anyhow," as one perfesser always says glib-like when the discussers get too hot and nobudy'll give an inch—and so she'd cum to where she cudn't settle down to learn annythin' for hersilf or by hersilf, as Abraham Lincoln said. And wan day, whin she'd been partic'lar stoopid, she jest pushed her glasses and spiders back, and said, lofty-like, "I don't approve av this way av studyin' at all. I don't want to *see* that a spider's got six legs. In Perfessor Black's class we'd *discuss* it." But the bug perfessor just said, "If the Lord's kindly left you the *wan* sinse of eyesight, that's wan av the manny things you *can't* discuss wid his *eight* legs stickin' right out in plain sight."

Manny's the time a discusser has interrupted a flow av rale knowludge, that'd make ye thrill, evin wid your feet the other side av the windy in the ice and snow, and I'll hear the passingers, as we called thim, heave a sigh as the same old discussers git up and say nuthin' at all. It's always the same discussers, about five or six to a class, maybe. And if they *av* to git what they don't know out av their system, you'd think they'd put thim discussers all in a class by thimsilves, where they cud waste their own time and let the rist av the class go on widout all this zigzaggin' round. But the perfessor is so busy holdin' fast to his lead-horse lines that he don't hear thim sighin' on the back seats. I expect the perfessors cum from the city and don't know about horses as we do, me b'y. For it ain't the prancin' leaders that really pulls the tally-ho, is it? And for all their

cavortin', the coach keeps to the same old road just the same. So their leadin', evin, ain't much to brag av. And did ye iver see a tally-ho team doin' anny rale work—and neither will you, me b'y. All ye kin say is they're havin' a good toime av it, but it's the hefty Percheruns ye see t' the coal wagons.

Some day the remarks av thim back seats'll git louder. They're a gittin' perty well bumped around, thim passingers, and they don't loike it. And the day av reckonin' is comin' whin they'll rise up and demand their rights, and we'll live to see it, be gorrah, fur it's cummin' soon.

Who knows but the Collige'll have guards to kape out thim discussers. There'll be me opporchunity, for I kin spot a discusser ivery toime. Fur what I've suffered from some av thim discussers, evin on the windy sills, which is remote, so to speak, wud make me the best bouncer on the force, and widout anny eye to the Carnegie medals, either.

And it'll cum, for this discussion way ain't what some av these perfessors think it is. For it's only a few that do the *discussin'* and whin they start, the majority begins a *cussin'*. And it's the majority that rules in this free country av America, praise be, except in prisidintial elections, av course.

RAINFALL AND GUNFIRE.

It is, of course, impossible to ascertain definitely whether bombardment can produce rain or not, because one cannot determine in any specific case what the rainfall would have been in the absence of bombardment. But there is a very widespread notion that gunfire may exercise an influence on the weather and there is always some one to seize upon any opportunity to show a possible connection between them. Since the experiments of C. T. R. Wilson showed that ions may act as nuclei for the condensation of water vapor, a new explanation has been put forward by several persons who claim that condensation may occur as a result of ionization of the air caused by bombardment.

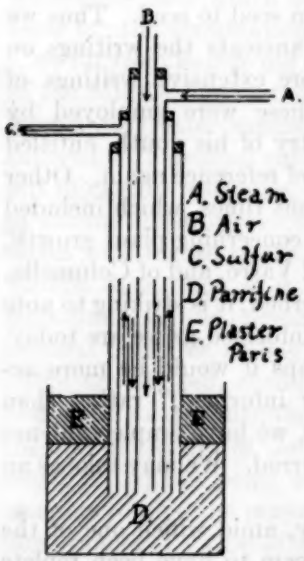
As a matter of fact, Wilson has shown that in order for the ions to be effective in producing condensation a "fourfold" degree of supersaturation is required for the negative ions, and a considerably higher degree for the positive. Others have shown that supersaturation is impossible so long as there are any particles of dust in the air. Dust is always found in the air, even in samples taken from the tops of high mountains far from towns. Consequently, we cannot suppose that ions are the immediate cause of any condensation produced by bombardment.

No rational account of any complete process by which gunfire could affect the weather has ever been put forward. Nor does the statistical evidence that is available support the proposition. It shows, rather, that the condition of the weather is a factor in determining the time of battles. An examination of the rainfall in France since the commencement of the war shows no outstanding features which could not be accounted for by the pressure distribution existing at the times of the individual falls.

A SULFUR WELL.

By Robert M. Ladd,
High School, Gary, Indiana.

Until recently the world has relied on Sicily for its supply of sulfur. Some years ago a great bed of this material was found to underly a large part of the states of Louisiana and Texas, but it lay beneath a bed of quicksand, which made it inaccessible by the ordinary means. For years it was untouched because no one could figure out a practical method of bringing it to the surface. Finally an American chemist developed a plan by which it could be melted in the deposit and forced to the surface as a liquid. A six inch cased well is driven. Inside of the casing three concentric tubes are placed. Steam under a pressure of 100 pounds is forced down one of these. Its temperature is about 160°C. As sulfur melts at 114°C., the mineral is liquefied. Hot compressed air is forced down through another of the pipes and the molten sulfur comes to the surface in the third.



I have found it somewhat difficult to make this process clear to my classes, so I have arranged a demonstration which is illustrated in the accompanying drawing. Because I had no way of generating my steam at any great pressure, I substituted paraffine for the sulfur.

Using this simple demonstration, I find that it is not difficult to make clear the process to even my sixth grade classes.

The apparatus was constructed of glass tubes of four different sizes. Side arms were sealed to each of the two tubes of intermediate size. The upper end of each of the three larger tubes was closed with a paraffined cork. I used an ordinary Florence flask as a steam generator. The compressed air was supplied by the foot bellows of our blast lamp. It was warmed before passing into the well.

The paraffine was melted and cast in a large beaker. The casing was sunk in this and then the paraffine was covered with about an inch and a half of plaster of Paris. This was to prevent the escape of the steam and the melted paraffine around the sides of the well.

RESEARCH IN CHEMISTRY.

Conducted by B. S. Hopkins,

University of Illinois, Urbana.

It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.

ON THEORIES CONCERNING SOILS AS MEDIA FOR PLANT GROWTH.[1]

By Chas. B. Lipman,

University of California, Berkeley.

In my humble opinion, one of the common and fortunate characteristics of thinking men is their propensity to theorize. Assuming that, it is but natural that, in the course of human experience, so vital a topic as the soil and its relations to plant growth should not have been overlooked in the making of man's theories. From early times in human history, there have descended records of direct or implied speculation on the mystery of the developing plant in its cycle from seed to seed. Thus we find in the very early records of the ancients the writings on agriculture of Hesiod, and the far more extensive writings of Mago, the Carthaginian general. These were employed by Virgil as a basis for the beautiful poetry of his youth, entitled the Georgics, to which I shall make brief reference again. Other famous writings on agriculture in ancient times, which included the prominent speculations of the day concerning plant growth, were the celebrated treatises of Cato, of Varro, and of Columella. Insofar as the art of husbandry is concerned, it is striking to note that the ancients were nearly as fully informed as we are today. Parenthetically, I may say that perhaps it would be more accurate, in one sense, to say "equally informed," rather than "fully informed." Of the truth of this, we have ample evidence in the writings to which I have just referred. We may take as an example the work of Virgil.

The pastoral scenes of ancient Italy, amid which one of the greatest of classic poets was reared, seem to have been replete with evidences of farming technique similar to our own. Moreover, there appears to have been known to Virgil many a tradition respecting agriculture which remains unchanged to this day in most farming communities. Indeed, there seems to be little in our farming methods which was not also known to Virgil,

[1]Read before Sigma Xi, April 24, 1918.

though we think now that we can, in a few cases, give better reasons for our procedures than could the ancients for theirs. I say better, advisedly, because most practices on our farms today are based on empirical tests which are far from being above question, even though they have been studied considerably. In the beautiful lines of the Georgics, we find exhortations on deep plowing, on fallowing, on timeliness of tillage, on the choice of heavy and light soils for certain groups of crops, respectively, and on many other phases of the subject of soil management, as well as on many other agricultural subjects. But even this keen observer, who sang the praises of the humble art of husbandry, was, like all other mortals, prone to theorize. For example, he connects the best times for tillage with the blowing of certain winds, and the presence of snakes in certain lands with the infertility of the latter. Thus, early in man's thought on soils and their productiveness do we have records of his speculations and theories. Such theories, it must be added, however, were arrived at by the deductive, rather than by the inductive method which we employ and which offers a more rational and more secure basis for the formulation of theory.

So far from improving on the ideas of the ancients, the writers of the Middle Ages actually detracted from their value by a relapse into greater superstition and less reason, and agriculture suffered with general culture from a lack, not only of attention, but of careful reasoning, of the making of rational theories, and of attempting to prove them. Those who would satisfy themselves with regard to the agricultural theory and practice of the Middle Ages, such as it was, are referred to August Meitzen's large tomes on the development of rural settlements and of agricultural practices among the Germanic peoples.

We are obliged, therefore, to continue the narrative on the history of soil fertility theory by bridging the large gap between the end of the era of the ancients and the end of the sixteenth century. At this point we begin to see attempts on the part of thinkers to give the reasons for the well-known effects of certain farm practices. One of such early attempts, extraordinary for its keen insight, was the statement cited by E. J. Russell from Palissy, a French thinker. This statement, made in 1563, puts forward the idea that manures have for their function the return to the soil of something which has been removed from it by plants; further, that all plants contain some kind of salt and that such salts are found in the ash of plants when the latter are

burned. Palissy, therefore, promulgated the hypothesis that the burning of straw in wheat fields returns essential salts to the soil from which they came, hence maintaining its productiveness. He finds in this idea the reason for what he believes to be the success of the burning of straw and stubble by grain farmers. While in our modern conceptions of the functions of organic and inorganic manures in soils there is no necessary confirmation of Palissy's speculations, the latter are at least rational and, in part, doubtless in accord with our important facts. The most remarkable feature of the theory, however, is that it is so very far ahead of its time. About two and one-half centuries were to elapse before so generally sound a hypothesis (in our view) could be fully appreciated and proved. Meanwhile, there was no lack of attempts, often resulting in a relapse into mediaeval vagueness, to account for the ever fascinating mystery of the plant. Whether such attempts are truly to be regarded as relapses and retrogressions or are to be accounted for by the lack of facilities for the dissemination of such speculations as Palissy's, cannot now be definitely ascertained. To assume the strong probability of the latter view, however, appears to be reasonable.

Whatever the cause of such apparent retrogression may have been, we find a considerable number of attempts in the two centuries following Palissy's utterance to find or to guess at the supposed "principle" of vegetation. Most prominent among such attempts is the celebrated experiment of Van Helmont, carried out toward the middle of the seventeenth century. This experiment, though much quoted by all writers on subjects involving plant growth, may perhaps be unknown to many of you and hence I beg the indulgence of the rest for presenting it now. Two hundred pounds of oven-dried soil were placed in an earthen vessel and moistened with water, and a willow shoot weighing five pounds was properly planted in it. The soil was protected against dust and wind by a perforated sheet of iron. Whenever necessary, rain water or distilled water was added to the soil to maintain optimum moisture conditions. Exactly five years after the experiment was started, Van Helmont found that the tree which had grown in that period from the willow shoot weighed about 169 pounds and 3 ounces. The soil was then again weighed and found to have lost about two ounces. Van Helmont therefore concluded that a little over 164 pounds in weight of wood, bark, and root (the leaves had not been collected and weighed as they fell) were built up of water, since nothing

else had been added to the soil during the period of the experiment. This famous experiment is of the greatest value to us, both because it illustrates admirably the seventeenth century theory with regard to soils and plants, and because it serves as an excellent example of the ease with which it is possible to draw erroneous conclusions from sound experiments. If Van Helmont had not disregarded the small but essential loss of two ounces from the soil, if he had thought of the part that the air might play in plant growth, he would not have concluded from the simple experiment just cited, as he did, that water is the "principle" of vegetation. The celebrated scientist, Robert Boyle, in his book entitled the "Sceptical Chymist," published in 1661, accepted Van Helmont's conclusion after having repeated the experiment with another plant and obtained similar results. Boyle went farther by distilling and analyzing his plants and obtained from them salt, spirit, earth, and oil. He could not resist the conclusion, therefore, that these substances must be produced from water in the process of the plant's growth. Again, therefore, a scientific man of high standing, and one to whom chemistry and physics owe much, fell a victim to a system of ratiocination which failed to take into account certain essential factors in the life of plants.

Johann Glauber, another celebrated chemist of the time, formulated a new hypothesis. This consisted of the theory that saltpeter or nitre is the "principle" of vegetation. Glauber's hypothesis was based on two observations: One that saltpeter was obtained from earth from cattle sheds; the other that applications of nitre to the soil gave astounding increases in the growth of plants. Since the earth in cattle sheds was affected by the urine and the droppings of the animals, Glauber assumed that the saltpeter was contained in them and was derived in turn from the plants which were eaten by the animals. In Glauber's view, therefore, the question of the fertility of soil resolved itself into one of supplying the necessary nitrates, and the value of various organic matters consisted in their properties of yielding nitrates to the soil. In the case of this hypothesis, it will be noted that both air and water seem to have been disregarded, other chemical substances ignored, and the fact that soils untreated with manure or urine might also contain nitrates seems not even to have been surmised; if it had been, Glauber's hypothesis might never have been made, or, at least, it would have been much modified.

Other theories of a similar nature to those of Van Helmont and of Glauber were not wanting at this period. Kulbel regarded humus as the source of a mysterious something which was the principle of vegetation. Another distinguished chemist, Boerhaave, in a textbook on chemistry, modified somewhat Glauber's view and stated his belief that a complex juice, "the chyle of the plant," toward which the animal, plant, and mineral kingdoms all contributed, constituted in the soil the principle of vegetation. All of these theories possess in common, however, the characteristic belief in one substance as the principle of vegetation, and the utter disregard of the factor of other variables than the one which they recognized as possibly being of some importance.

A somewhat different view and attitude on this subject was introduced, however, in the third decade of the eighteenth century by Jethro Tull. Tull was a man of an inventive turn of mind, who possessed very definite ideas and entirely unique ones with respect to the nutrition of plants. He was the inventor of the seed drill and the horse cultivator and published a book in 1730 entitled "Horse Hoeing Husbandry." His interesting, and to us now risible, theory was that plants utilized the fine particles of soil as food directly, provided only they were fine enough. These very fine particles constituted, in Tull's own picturesque language, "the proper pabulum" of plants and were ingested by the swelling of the roots following moisture absorption, and through the pressure thus exerted forcing the particles into certain hypothetical "lacteal mouths of the roots." With this view on the nutrition of plants as a basis, Tull urged most emphatically the importance of constant tillage, whereby he believed it possible to reduce the sizes of the individual soil particles to a point which would permit of their absorption into the circulatory system of the plant as just described. As a corollary to his theory, Tull expressed his belief on the incorrectness of the view that different plants require different soils and that if given a thoroughly tilled soil, any of them will do well on any soil and will absorb any kind of substances presented to the roots; also that the fining of the soil aided in its absorption of certain gases from the atmosphere which he considered in some mysterious manner as being "nutritious." In general, Tull's ideas on plant nutrition are expressed in the following words from his own pen: "It is agreed that all the following materials contribute in some manner to the increase of plants, but it is disputed which of them is that very increase or food: (1) nitre,

(2) water, (3) air, (4) fire, (5) earth." The strikingly novel feature of Tull's hypothesis, therefore, inheres in his consideration of the soil particles as constituting the food of plants. Aside from that idea, he seems to have been troubled about finding some one thing of those just mentioned which was responsible for plant growth and thus did not differ essentially from his contemporaries or predecessors.

In the four decades following the appearance of Jethro Tull's interesting book, no theories were put forward either in England or on the continent which constituted distinct steps forward in the solution of the problem of plant growth as viewed today. To be sure, that period differed from the foregoing in that experiments came into vogue and attempts were made to determine the composition of the plant by such methods as were then available and to account for the effects of salts, alkalies, and other materials, when applied to soils. The outstanding work of that period is probably that of Francis Home, published in 1756, and entitled "The Principles of Agriculture and Vegetation," written as a result of experimental work which Home started at the solicitation of the Edinburgh Society. In this period, too, the hypothesis of Külbel, or a form of it, to the effect that humus is the source of food for plants, was revived by Wallerius and is of interest here mainly because such revival served to perpetuate the idea on the continent of Europe, at least to some extent, until Liebig's day. The humus theory was indeed no improvement on much earlier statements such as those of Lemery, who wrote in that vain on nitrification and on certain phases of plant nutrition as early as 1717. The state of relative stagnation of soil theory, which characterized the period under consideration, viz., that between 1730 and 1770, is merely a reflection of the status of science in general at that time. In certain of the works on chemistry of the day, we find ample evidence of a vagueness and a crudity of conception on relatively simple matters, which are astounding to us and which constitute evidence of the dazzling progress achieved by the science of chemistry since then—a space of about one century and a half only. As an instance of the kind of conceptions which were not merely current in those days, but considered most advanced, permit me to cite a statement concerning nitric acid, extracted from Crell's "Die Neuesten Entdeckungen in der Chemie," published about 1767. Crell says:

"Chemists differ as to the origin and essential constituents of

nitric acid. Some regard it as a peculiar body floating in the air and following the north and west winds; some as a product of decay; some believe that it originates from common salt; and the majority and most up to date regard it as derived from carbonic acid gas, which is a spirit of vitriol."

This state of knowledge, or lack of it, on the continent is further attested by the fact that the Berlin Academy of Sciences awarded a prize to a chemist by the name of Pietsch, who proved, as he thought, that saltpeter is not a salt and that "nitric acid consists of a fine fatty substance or combustible."

Small wonder, then, that little progress was made in soil theory during the period in question. With progress in chemistry and in physics wanting, the intellectual impetus to and sinews for a better understanding of the plant organism and the soil was also lacking. But a new era of thought was ushered in, in about the year 1770. In England, at least, but also in Switzerland and Holland, a new generation of chemists was beginning to make an impression through its advanced thinking and experimenting, and through its overwhelmingly important discoveries. Thus Priestly, Scheele, Ingen-Housz, Senébier, and de Saussure are names to conjure with in any generation of scientists. This was a generation of investigators who appeared to see the hopelessness of working on problems with many variables, who appreciated the inadequacy of the all-inclusive and yet impotent theories of Tull, Külbel, Lemery, Wallerius, and Berzelius, and who, therefore, attempted to take one step at a time in studying the mystery of plant nutrition. In 1771, Priestley attempted to determine what effect, if any, plants exerted on air vitiated by such phenomena as combustion, putrefaction, or animal respiration. He used sprigs of mint and found that air like that described could be purified by that plant. From this fact he concluded, erroneously, however, that the process of respiration in plants was essentially different from that in animals, the first being such as to purify and the second such as to vitiate air. This work preceded Priestley's discovery of oxygen and, therefore, lacked a certain definiteness and precision which it would doubtless have had otherwise. That was not the only reason for the erroneous conclusion, however, since Priestley persisted in it even after he had discovered oxygen, because he failed to take into account the effect of light on the power of plants to affect the condition of the atmosphere. The difference of opinion arising between Priestley and Scheele, who insisted that

plants, like animals, vitiated the air, remained for Ingen-Housz to reconcile. He showed that both Priestley and Scheele were right, that purification of air by plants goes on in light only, while vitiation of air by them goes on in darkness. It was thus demonstrated that the plant had a definite effect on the atmosphere and a great step was taken in the progress of plant physiology. In 1782, Jean Senébier not only confirmed the findings of Ingen-Housz, but also carried out investigations on the reciprocal problem of the effect of the atmosphere on the plant. As a result of these studies, he attributed the weight of the willow tree in Van Helmont's experiment to what he called "l'air fixe." We find thus the first rational view on the rôle of the atmosphere in plant life in the experiments and discussions of Senébier. With the exception of the studies of de Saussure, which I shall allude to presently, there is probably nothing of such towering proportions in the progress of plant physiology, considering the radical departure which it represented from the views of the foregoing ages, as the group of researches to which I have so briefly referred as beginning with Priestley and culminating with the brilliant discoveries of Senébier. They were all characterized by a freshness, a simplicity, and a directness which, in the midst of such dominating crudities as those which I have cited in the chemistry of their day, makes them stand out with a boldness and isolation which not only mark the beginning of a new and progressive era, but which typify the results of great thought and great achievement, stimulated by the unusual imaginations of all time.

A period covering nearly a quarter of a century was to elapse, however, before further progress, with Senébier's striking and important discoveries as a basis, was made. It appears that that was not a period of inactivity so much as one of preparation. The satisfactory corroboration of Senébier's explanations on the relations of plant and air required more than the mere continuation of his tests, which were largely qualitative in nature. The progress of the subject then required recourse to the quantitative method, which still remained to be developed. This was forthcoming, however, in the work of Theodore de Saussure, and proved the latter to be a man of surpassing genius and industry, and insured for him a place of distinction in the most exclusive "hall of fame" which the annals of science have established for all ages. It appears from Senébier's statements that de Saussure's father was well acquainted with the work of the former and hence

we have the probable reason for Theodore de Saussure's study in a quantitative manner, among other things, of the relation of plant to air, which absorbed the interest of Senébier. Employing methods of astounding simplicity and precision, considering the state of knowledge of the day, de Saussure demonstrated the existence of plant respiration. He showed by careful eudiometric measurements the amounts of oxygen which plants absorb and the quantities of carbon dioxide which are evolved. He established the fact that carbon dioxide is decomposed by plants in the presence of light, with the resulting evolution of oxygen. He, therefore, made it perfectly clear that carbon dioxide in small quantities in the atmosphere was indispensable to plants, that it furnishes them with carbon and with some oxygen, that water is decomposed by plants and employed with carbon in the synthesis of carbohydrates.

But de Saussure further showed by quantitative measurements that nearly all of the dry weight of plant substance is obtained from the air, that only a very small part comes from the soil, but that nevertheless that small part is absolutely essential to the life of the plant. He argued, moreover, from the results of his experiments, against such ideas as those of Tull anent the inability of plant roots to select certain constituents from the medium in which they grow and to leave others untouched. Thus, he believed that membranes of root cells permit water to pass through more readily than salts and hence tend to cause increased concentrations of the medium surrounding them; also that they permit different salts to enter with different degrees of facility. He studied the composition of plant ash and demonstrated that it varies with the nature of the soil and with the age of the plant, and that it consists largely of the alkalies and phosphates. He pointed out the fallacy of the ideas of Kirwan and Lampadius, promulgated as late as 1796, that plants produce potash and silica, by showing that plants grown in water show no gain in ash, and that there is just as much found at the end of the growing period as is contained in the original seed and no more. Last, but not least, de Saussure demonstrated that the small portion of the dry matter of the plant which comes from the soil supplies nitrogen, which is essential to plants and which cannot be assimilated by the latter directly from the air. This idea should be noted particularly, since it was not adhered to by de Saussure's distinguished successor, Liebig, and was the cause of a controversy which was not ended until past the middle of the last century, when it was decided in favor of de Saussure's view.

All of this work was done in the most careful manner, every step in progress was checked, and no superfluous steps were taken. The beautiful simplicity of de Saussure's account of all this work entitled "Recherches Chimiques Sur la Vegetation" and published in Paris in 1804 cannot be overemphasized. In a small duodecimo volume of 327 pages and a few plates, he sets forth with clearness and brilliance all the essentials of the vital subject of plant nutrition in much the same form as we accept them today. To a student of de Saussure's clear, concise, and experimentally supported statements, the work appeals as would a Velasquez or a Titian to an art lover. One can see in it the bold and effective stroke of the master hand impelled by the master mind, and the color of the artist finds its analogy in the penetrating logic and ingenious experiment of the scientist. De Saussure painted with a large brush on a gigantic canvas.

The remarkably lucid and amply supported statements of de Saussure were, however, largely disregarded in Europe and particularly on the continent. The old humus theory was still in vogue and was, partly or wholly, supported by such eminent scientists as Sir Humphry Davy and Berzelius, the former writing it into his textbook on agricultural chemistry nearly a decade after the appearance of de Saussure's little volume. So far from adding to de Saussure's splendid contribution, many of the writers of the day, then, denied the truth of some of the most fundamental ideas so carefully and laboriously established and so clearly and simply propounded by de Saussure. In the decade between 1830 and 1840, considerable work of interest was being done, for example, the work of Sprengel on the ash constituents of plants, the work of Schübler on soil physics, the excellent quantitative work of Boussignault in field experiments, and the work of Liebig in agricultural chemistry. Only the last named deserves attention in connection with soil theory, however, since none of the others changed fundamentally de Saussure's conceptions with regard to the soil as a medium for plant growth and particularly on the subject of plant nutrition. The work of Liebig, however, deserves special consideration, not because he added much that was new, for he actually added little that was fundamentally different from de Saussure's teaching and in fact attempted to change some of the latter to their detriment, but because of the position which history has accorded him and because he succeeded in elaborating and making men generally accept the discoveries of de Saussure.

At the request of the British Association, Liebig made a report on the state of organic chemistry. This celebrated document was published in 1840, under the title "Chemistry in its Application to Agriculture and Physiology." In this book, which quickly went through several editions, Liebig took to task the chemists and physiologists of the day for the crudity of their ideas in the light of de Saussure's discoveries over a generation before. He attacked and completely demolished the humus theory, though it appears to me that his claims as to the general acceptance of that theory in those days were much exaggerated, to judge particularly from the literature of British scientists of the day. He defined more sharply than de Saussure had done some of the more detailed phases of the functions of the mineral elements in plant growth. He gave a detailed account of the respiration process in plants and of his ideas on the fixation of carbon and hydrogen. He put forward the hypothesis that roots of plants excrete acetic acid, which serves to dissolve the minerals of the soil and thus to render available elements essential to plant growth. He set forth the unequal solubilities of the compounds in soils. He believed that plants will absorb all constituents of solutions readily and will excrete such as are not necessary in their growth, and that they obtained their nitrogen from the ammonia of the air.

As can readily be seen, these were, more strictly speaking, amplifications and elaborations of the earlier ideas than new ideas in themselves. Indeed, a number of them have since been proved to be partially or wholly incorrect, but these will be considered later. It is most striking in Liebig's work to note the poignant sarcasm by which he awakened the scientific world to a realization of its backwardness, by which he forced it to examine existing ideas critically and to accept only such as were in accord with outstanding facts and the soundest theories. As characteristic, it may be interesting to quote Liebig's manner of accounting for the non-acceptance in full of the theories and experiments of de Saussure and his supporters. He says:

"All this is due to two causes which we shall now consider.

"One is that in botany the talent and labor of inquirers has been wholly spent in the examination of form and structure: chemistry and physics have not been allowed to sit in council upon the explanation of the most simple processes; their experiences and their laws have not been employed through the most powerful means of help in the acquirement of true knowledge. They have not been used because their study has been neglected.

"All discoveries in physics and in chemistry, all explanations of chemists, must remain without fruit and useless because even to the great leaders in physiology"—and he might have added in chemistry—"carbonic acid, ammonia, acids, and bases are sounds without meaning, words without sense, terms of an unknown language, which awaken no thoughts and no associations. They treat these sciences like the vulgar who despise a foreign literature in exact proportion to their ignorance of it, since even when they have had some acquaintance with them, they have not understood their spirit and application.

"Physiologists reject the aid of chemistry in their inquiry into the secrets of vitality, although it alone could guide them in the true path; they reject chemistry, because in its pursuit of knowledge, it destroys the subjects of its investigation; but they forget that the knife of the anatomist must dismember the body, and destroy its organs, if an account is to be given of their form, structure, and functions. . . .

"The second cause of the incredulity with which physiologists view the theory of nutrition of plants by carbonic acid of the atmosphere is that the art of experimenting is not known in physiology, it being an art which can be learned accurately only in the chemical laboratory. . . ."

It is not surprising that such statements aroused the slumbering spirits of the doubly conservative physiologists and chemists of Liebig's time. In later editions of his book he formulated two so-called laws: first, the Mineral Law—"the crops on a field diminish or increase in exact proportion to the diminution or increase of the mineral substances conveyed to it in manure"; and, second, the Law of the Minimum—"by the deficiency or absence of one necessary constituent, all the others being present, the soil is rendered barren for all these crops to the life of which that one constituent is indispensable."

As time went on, moreover, Liebig came to believe more and more firmly in two theories: first, that the needs of crops for minerals are indicated by the composition of the ash, and second, that plants can obtain from the air the nitrogen which they need. He believed that the latter idea was borne out by the longevity of certain Dutch, Hungarian, and American soils, and further that on the basis of these two ideas we should merely have to analyze the plant ash and the soil, and draw up certain tables for use by the average farmer with regard to the fertilizer needs of his crops and soils in the form of minerals only.

(*Continued in December.*)

BOLSHEVIK MULTIPLICATION.

By H. J. R. Twigg.

Certain South Russian peasants are able to multiply together figures no matter how large, and yet do so while *unable to do anything more than double, halve, add, or subtract*, and not understanding fractions; any such arising have to be ignored. The *modus operandi* is as shown in four examples:

No. 1. Multiply (say) 40×25:

(i) Put 40 at the top of the left-hand column (or *vice versa*).
(ii) Put 25 at the top of the right-hand column to match.
(iii) Go on halving the left hand.
(iv) Go on doubling the right hand.

Ignore left hand. Total up right hand (*except* where left-hand figures are even).

L.	R.
40	25
20	50
10	100
5	200
2	400
1	800
	1000

No. 2. Say 28×10:

L.	R.	
28	10	Not added, 28 even
14	20	Not added, 14 even
7	40	½ of 7 = 3½. The ½ ignored
3	80	½ of 3 = 1½. The ½ ignored
1	160	
	280	

No. 3. Say 9×6:

L.	R.	
9	6	½ of 9 = 4½. The ½ ignored
4	12	(4 is even)
2	24	(2 is even)
1	48	
	54	

No. 4. Say 28×19:

L.	R.
28	19
14	38
7	76
3	152
1	304
	532

Correct every time!

Can any readers of *School Science and Mathematics* explain the principle involved in these operations or throw any light upon its origin?—[School *World*.

LOAN $7,097,000,000 TO ALLIES.

Up to date the United States has loaned the allies $7,097,000,000, of which $6,377,787,895 has been expended in this country in purchasing their obligations for munitions, food, etc. The allies still have a large balance to their credit in the treasury.

A NEW METHOD OF MAPPING COMPLEX GEOGRAPHICAL FEATURES, ILLUSTRATED BY SOME MAPS OF GEORGIA.

By Roland M. Harper,
College Point, N. Y.

Ever since geography became a subject for scientific investigation it has been the aim of geographers to represent the various complex features of the earth's surface, such as topography, soil, climate, vegetation, population, agriculture, etc., on maps in as rational and obvious a manner as possible. When each of these features is resolved into its components it is a simple matter for anyone who has the necessary data to map one component at a time, in a manner which may require some skill but leaves little room for difference of opinion; and if they do not conflict too much two or more components may be put on the same map.

For example, altitude, the principal component of topography, is easily represented by contour lines. Soils may be mapped according to the percentage of some one physical or chemical constituent, such as fine sand or silt, or calcium or phosphorus. Innumerable climatic factors, such as temperature and rainfall (average, maximum, minimum, seasonal, departure from normal, etc.), length of growing season, and average date of arrival of spring, are easily mapped, singly or two or three together. (The daily weather maps with which we are all familiar show temperature, barometric pressure, and one or two other things.) In mapping vegetation we may indicate the distribution of one species at a time, by means of dots, boundary lines, or shading, or we may map several species at once if they do not overlap too much. We might also indicate the percentage of evergreens, or of plants belonging to a given family, in each state or county or natural region, by appropriate shading. Under the head of population we can indicate density by dots or otherwise, and rate of increase in a given period, proportion of negroes, foreigners, tenants, etc., by shading.

But routine work of the kinds mentioned is mere cartography, or chorology, rather than true geography, and can be undertaken just as well by topographers, climatologists, botanists, demographers, etc., as by geographers. Furthermore, if we mapped only one thing at a time we would need innumerable maps to show all the geographical features of any region, and they would fail to give the user a good mental picture of the region. The geographer therefore seeks to put as many things

as possible on one map; but not everything, for that would be simply chaos. This calls for considerable skill in generalization, and often some artistic talent besides, as for example in making topography more legible to untrained persons by using hachuring instead of contours.

Climate and population are so complex that it would probably be impossible to put all the features of either one on one map and still have it intelligible. In mapping crops the principal difficulty is one of generalization. On a map of sufficiently large scale one could show every field with its particular crop, but on the scales ordinarily used that would be out of the question, and one would have to resort to some such expedient as determining the leading crop in each area, and mapping a corn region, a wheat region, a cotton region, etc. In mapping soils and vegetation one would have the same difficulty, plus the much greater one of deciding just where to draw the line between different types, which might intergrade in all sorts of ways. Detailed soil maps of several hundred counties have been published by the U. S. Bureau of Soils, and one needs only to compare the maps of neighboring or similar counties made several years apart, or by different men, to see how much individual judgment may vary in classifying the soils. The few soil maps of the whole United States that have been published (see for example those in Bulletins 85 and 96 of the Bureau of Soils) are primarily soil province maps, based on geology, topography, etc., and tell very little about the soils themselves. Pretty good vegetation maps have been made of some small areas, but all the existing ones of whole states and larger areas are far from perfect. (The latest of North America is that of Harshberger in his *Phytogeographic Survey of North America*, 1911[1], and the latest of the United States is that of Shreve in the *Geographical Review* for February, 1917.[2])

The writer has gradually evolved (but cannot say perfected) a method of mapping soils, vegetation, crops, and some other complex features, which though it involves no radical innovations is probably an improvement on any now in use. It does not fulfill the ideal of putting everything on one map, but it shows at a glance the prevailing type of soil, forest, etc., in the areas mapped, and has the special advantage of leaving very little to individual judgment after the facts are gathered in

[1]Reviewed in *Bull. Am. Geog. Soc.*, 45:38-42, January, 1913.
[2]Reviewed in *Torreya*, 17:103-106, June, 1917.

sufficient detail and the regional boundaries located. It might be called the quantitative regional method.

The first aim of the geographer in studying any considerable part of the earth's surface, such as a state or country, should be to subdivide it into areas as homogeneous as possible, to give a *maximum of contrast* between neighboring divisions and require the least possible repetition in describing them. Just how finely one should subdivide is largely a matter of judgment and expediency and the scale used. Small areas are generally more homogeneous than large ones, but if we make them too small they will also be too numerous and too much alike. The boundary between any two neighboring regions should correspond with a comparatively abrupt change in one or more geographical features, whether topography, soil, vegetation, or something else. Of course in many cases we can find no sharp boundary between regions that are obviously different on the whole (especially if the principal difference is a climatic one), and must draw the lines more or less arbitrarily. Again there may be differences of opinion as to what sort of differences should be taken into consideration, what are major and minor regions, etc. But these difficulties are nothing new to scientists, being inherent in taxonomy. They have been met thousands of times in classifying geological formations, minerals, soils, plants, animals, etc., and some have been settled while others are still in dispute.

There have been many attempts to map the geographical divisions of North America or the United States, some of which suffer from the narrow point of view of the author, who may be primarily a physiographer, climatologist, botanist, or demographer, rather than an all-round geographer.[3] But plants are not classified by their leaves, flowers, or fruits alone, or animals by their skeletons or teeth alone, but all possible characters are taken into consideration, as should be done likewise with geographical divisions. A geographical map based primarily on topography (like Fenneman's) does very well in parts of the country where there is considerable relief, but in the coastal plain we often find regions much alike in topography differing considerably in soil and therefore in vegetation and agricultural features, if not also in density and composition of population.

But taking for granted that our geographical boundaries

[3]Several of the attempts to subdivide North America have been summarized by Joerg in the fourth volume of the *Annals of the Association of American Geographers* (1915). The latest on the geography of the United States is by Fenneman in the sixth volume of the same (1917).

have been agreed upon, we now come to the main issue, of mapping the complex features of each region. The method is simply to take one group of features at a time, that can be measured in the same units, compute statistics for one region at a time, and put the different features in each class on the map *in order of abundance or importance*, indicating them by words of symbols, and using percentages if possible and desirable. For example, soils are divided into types and measured by acres or square miles, vegetation is divided into species and measured in feet of timber or tons of hay, and crops may be measured by either acreage or value.

For many regions in the United States we now have enough Government soil surveys to be fairly representative, and in all but a few of the earliest ones (published about the beginning of this century) the area of each type of soil is given, so that we can add up all the stony clays, fine, sandy loams, etc., and determine the percentage of each. The errors of judgment mentioned a few pages back are just as likely to be in one direction as in another, so that they tend to neutralize each other when several reports on different parts of the same region are available.

For vegetation we have very few reliable quantitative data as yet, except for a few small areas; but the writer by traveling through every known natural division of the southeastern states, by rail or on foot, or both, and jotting down the name of every plant recognized as often as possible, and consolidating the returns afterward, has determined the approximate relative abundance of all the commoner and more conspicuous plants, particularly trees, in that part of the country, and has made a beginning in a few of the northern states.

For crop statistics we have to depend chiefly on Government census reports, which are not altogether satisfactory. Considerable information is given about the yields of different crops in every county, but they are not reduced to a common unit; cotton, for example, being returned in acres and bales, and apples in trees and bushels. Again, pumpkins, watermelons, cabbages, tomatoes, onions, lettuce, and many other things are lumped together under the head of "vegetables." For the whole states the crops are subdivided more minutely in the general volume on agriculture, of the last census, but not in the state supplements; and state statistics are of little use to geographers, for every state in the Union has at least two natural divisions, and

some as many as twenty. There is, however, a way of circumventing some of these difficulties. In each state supplement the total value of each kind of crop (except where different things are lumped together as above indicated) is given, and by dividing this by the number of acres, bales, pounds, or bushels we can get the average value per unit for that state, which we may assume without serious error to be the same for every subdivision of the state. This gives us a means of reducing the county crop statistics to a common unit. Although value varies considerably at different times and places, it is a better criterion for comparison than acreage, for an acre of strawberries or lettuce, for instance, is worth far more than an acre of corn or wheat, because it requires so much more labor for planting, harvesting, etc.

Some of the states gather agricultural statistics of their own which are more complete than the Government statistics, but this does not happen to be the case with Georgia, the one selected for illustration. The crop statistics published biennially by the Florida Agricultural Department give the value of every important crop (separating all the different vegetables) in every county, and these were used by the writer a few years ago in determining the principal crops in all parts of northern Florida.

In putting these features on maps one map should be used for each kind, and the names of as many things as there is room for printed right in the proper spaces, in order to abundance, or area, or value, as the case may be. The differences between any two neighboring regions in that particular are then very evident. Abbreviations or symbols can be used to save space when necessary, and regions too small to put anything in can either be left blank (being of little importance with reference to the whole area mapped), or else their features can be printed out in the margin somewhere and connected with the proper region by a guiding line. As a region which extends through several states but is commonly regarded as a unit (like the Piedmont region and the Appalachian valley) may vary somewhat in different parts, on account of gradations of elevation, climate, or something else, it is well to work out the statistics for each state separately and map them accordingly, to show just what the variations are. Of course the method here described is just as applicable to political divisions as to natural geographi-

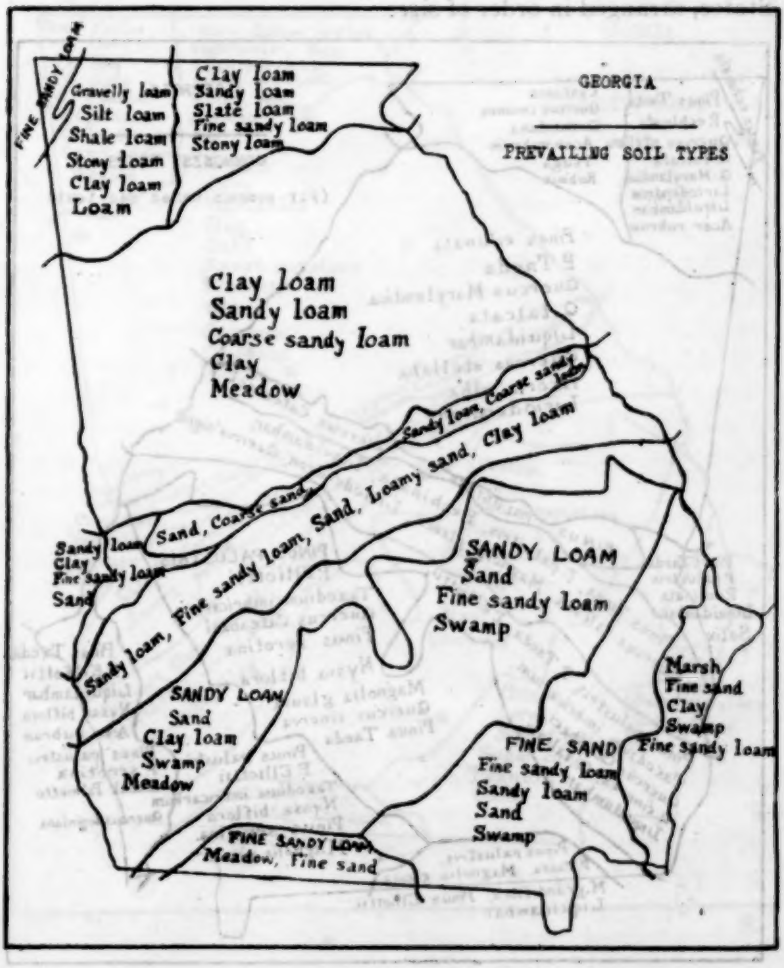
[4] See 6th *Ann. Rep. Fla. Geol. Surv.*, pp. 188-189, etc. 1914.

cal divisions, but to use political divisions alone would be unscientific, and would sacrifice the fundamental principle of maximum contrast to expediency. However, where we are not sure of the natural boundaries we may take certain crops of counties for trial, and after computing statistics for them find that shifting a certain county from one region to another gives more contrast, and thus gradually make our regions more nearly natural.

If we had county statistics of manufacturers they could be mapped in the same way as crops, but unfortuntately the Government publishes manufacturing statistics only for states and

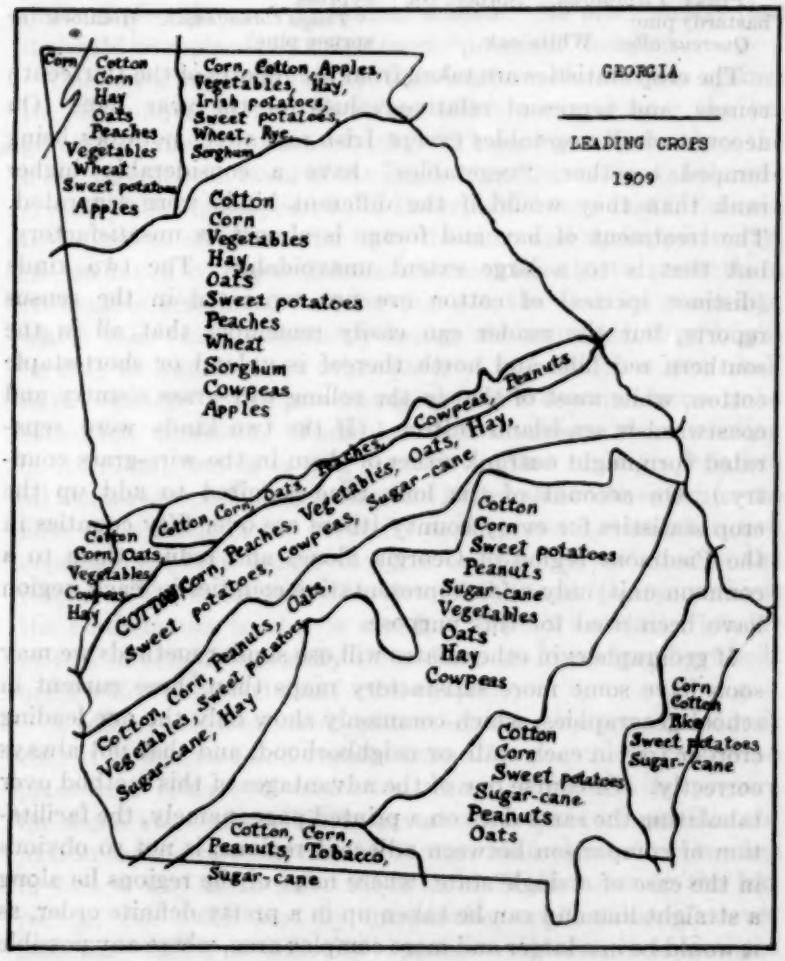
principal cities. Climate and population do not lend themselves well to this sort of treatment, but their salient features for each region might be put on the map in a few words. Topography could be treated statistically, if one wanted to take the trouble to do it, by estimating the area lying between 0 and 100 feet altitude, 100 and 200, etc.; and this was actually done for the whole United States in the tenth census, and correlated with population, etc.

The principles here discussed will now be illustrated by four maps of Georgia. The first shows the names of the twelve subdivisions, the second the soils, the third trees, and the fourth crops. The four northernmost divisions belong to the highlands, and the remainder to the coastal plain. Their boundaries



are based largely but not entirely on geological formations. On the last three maps the aim has been to list everything that makes up as much as five per cent of the total. Approximate percentages could have been given in every case, but the fundamental data are not yet accurate enough to justify the undertaking. (Perhaps they will be after the next decennial census.) But to give some idea of abundance, wherever an item at the head of a list is believed to constitute over half the total, its name is printed in capitals. (If one had the necessary skill and patience each name could be written in a size proportionate to the abundance of the thing named.) It is useful to bear in mind that the percentages of abundance tend to form a geometrical progression, like the populations of the cities of the United States, arranged in order of size.

The soil data have been taken from the Government soil surveys published up to the end of 1916, of which there are about forty-two for Georgia. The information about vegetation is based wholly on personal exploration, and covers only the trees, which are the most conspicuous and important part of the vegetation. Technical names are used because they are more definite, the same common name often being applied by the natives in different regions to two or more distinct species of trees. For the benefit of nonbotanical readers a glossary of the names used is appended here. Where only one species of a genus appears on the map the specific name is omitted to save space.



Acer rubrum. Red maple.
Castanea dentata. Chestnut.
Fagus grandifolia. Beech.
Hicoria alba. Hickory.
Liquidambar Styraciflua. Sweet gum.
Liriodendron Tulipifera. Yellow poplar.
Magnolia glauca. Bay.
Magnolia grandiflora. Magnolia.
Nyssa biflora Black gum.
Pinus echinata. Short-leaf pine.
Pinus Elliottii. Slash pine.
Pinus glabra. Spruce pine.
Pinus palustris. Long-leaf pine.
Pinus serotina. Black pine.
Pinus Taeda. Short-leaf (or loblolly) pine.
Pinus Virginiana. Spruce (or bastard) pine.
Quercus alba. White oak.
Quercus Catesbaei. (Forked-leaf) Black-jack oak.
Quercus cinerea. Turkey oak.
Quercus coccinea. Spanish oak.
Quercus falcata. Red oak.
Quercus Marylandica. (Round-leaf) Black-jack oak.
Quercus montana. Chestnut oak.
Quercus nigra. Water oak.
Quercus stellata. Post oak.
Quercus Virginiana. Live oak.
Robinia Pseudacacia. Black locust.
Sabal Palmetto. Cabbage palmetto.
Salix nigra. Willow.
Taxodium imbricarium. Pond cypress.
Tsuga Canadensis. Hemlock (or spruce pine).

The crop statistics are taken from the reports of the thirteenth census, and represent relative values for the year 1909. On account of all vegetables except Irish and sweet potatoes being lumped together, "vegetables" have a considerably higher rank than they would if the different kinds were separated. The treatment of hay and forage is almost as unsatisfactory, but that is to a large extent unavoidable. The two kinds (distinct species) of cotton are not separated in the census reports, but the reader can easily remember that all in the southern red hills and north thereof is upland or short-staple cotton, while most of that in the rolling wire-grass country and coastward is sea-island cotton. (If the two kinds were separated corn might outrank either of them in the wire-grass country.) On account of the long time required to add up the crop statistics for every county (there are over fifty counties in the Piedmont region of Georgia alone) and reduce them to a common unit, only a few representative counties in each region have been used for this purpose.

If geographers in other states will use similar methods we may soon have some more satisfactory maps than those current in school geographies, which commonly show only the one leading crop or tree in each state or neighborhood, and that not always correctly. Of course one of the advantages of this method over tabulating the same data on a printed page, namely, the facilitation of comparison between adjacent regions, is not so obvious in the case of a single state, where most of the regions lie along a straight line and can be taken up in a pretty definite order, as it would be in a larger and more complex area, where any possible linear sequence would separate some adjacent regions.

MATHEMATICS AND EDUCATION.

By L. E. Mensenkamp,
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Most mathematical activity is carried on in connection with educational institutions, and therefore the casual observer might expect to find that the veiws of the mathematics teacher, the educator, and educational administrator were in one accord on questions concerning educational values and the place of mathematics instruction in the curriculum. That such is not the case, however, is a matter of common observation. The educator of today is often rather skeptical of the value of mathematics and is rather inclined to question its right to its traditional place in our educational scheme. He often thinks that it should be replaced by other more "practical" subjects.

One of the causes of this attitude has been the reaction against the doctrine of formal discipline which occurred near the beginning of the twentieth century. There was a time when the main argument in favor of the study of mathematics was the one given by the philosopher, John Locke, which was that it "should be taught to all those who have the time and the opportunity, not so much to make them mathematicians as to make them reasonable creatures, that having got the way of reasoning, which that study necessarily brings the mind to, they might be able to transfer it to other parts of knowledge as they shall have occasion." The present status of this doctrine seems to be somewhat uncertain. There has doubtless been some reaction in its favor, but it is still possible to find among specialists all shades of opinion regarding it. Many elaborate experiments have been made either to verify or disprove it, but often two experts have been unable to agree on the interpretation of the results of the same test. In view of this uncertainty, perhaps the mathematics teacher is wise not to push his claims too far in this direction, especially since there are other good grounds upon which to base claims for his subject.

A second criticism made of mathematics by the educator is that it is abstract and remote from life, and therefore has no place in a scheme of education whose business is to prepare for social efficiency. Efforts have been made to meet this objection during recent years by reorganizing elementary courses in such a way as to defer the more difficult topics to the last part of the course and by introducing applications wherever possible. Here, a difficulty appears. Educators sometimes

seem to judge the entire utility of algebra for the student by the usefulness and applicability of the problems in the first courses. They seem to forget that beginning students have not at their command a sufficient body of elementary facts from the fields in which mathematics finds its most interesting applications to solve and appreciate problems taken from these fields. The full value of mathematics is not to be estimated from the first-year courses alone, but rather by the use which may be made of it in later work. The mathematicians have, perhaps, been too reticent on the question of applications. They study their subject chiefly because of the aesthetic pleasure which they experience in observing the harmonious relationships of number and form, but they must not forget that outsiders are, in most cases, utilitarians whom it is wisest to meet on their own ground.

The theory of statistics may serve as a bond to bring the mathematician and the educational theorist closer together in the future; it may bring home to the latter something of the practical value of mathematics. The schoolman of today is interested in the objective facts of the educational process; he is trying to found a science based on observation and experiment; he is trying to treat educational problems *quantitatively*. To do this properly, he must borrow tools forged by the mathematician for the treatment and analysis of statistics. For example, it is desirable for him to know the properties of the probability curve, $y = y_0 e^{-ax^2}$. Among other things, he must know the area under all or any portion of this curve. What a world of results from the realm of pure mathematics are implicitly related to this problem—properties of exponential functions, transcendence of e, the properties of infinite series, evaluation of infinite integrals, and so on.

There is a prevailing impression, too, that the applications of mathematics are confined to engineering; so that the prospective engineer is the only person benefited by its study. This idea surely needs correction. Mathematics is coming into wider use in other fields of endeavor every day. In psychology, sociology, and biology, the relations between certain groups of phenomena are being treated by mathematical methods and exhibited by means of correlation-coefficients and correlation-ratios. In economics, Professor Fisher has shown[1] that the general price level, that "high cost of living" which we are all so anxiously interested in these days, is dependent upon five

[1] I. Fisher, *Why the Dollar is Shrinking*, p. 75.

other variables, and that the relation may be expressed *algebraically* in an equation of exchange. A recent writer on agriculture, at the close of an article dealing with the relations between plant growth and the chemical conditions of the soil, and involving some mathematics, remarks significantly, "It seems a far cry from the logarithmic curve expressing an absorption isotherm to the management of barley and turnips, but the relation is really simple and direct . . . ."[2] Illustrations like these might easily be multiplied.

But it is not sufficient that mathematics *is* useful; that usefulness must be made known to the public. The mathematics teacher of today must be a propagandist; he must use every legitimate means to bring the importance of mathematics to those outside of the schools, so that they may better appreciate the worth of the enterprises upon which he is engaged. In the classroom, let him do as much as the immaturity of his audience will permit to suggest the human significance of mathematics. More than this, he should miss no opportunity to cultivate an appreciation of his subject on the part of those whose opinions direct school policies. The speeches which high school teachers are often called upon to make at gatherings of parents and teachers offer opportunities along this line.

The teacher should also see that the public library in his community is equipped with at least a few good mathematical books. Strange to say, there are libraries in cities of populations of thirty or forty thousands of people which are entirely without books on mathematics. After the books are in the library, he must do what he can to influence people of the right kind to read them. In these and other ways which will readily suggest themselves, the aggressive teacher can help to bring about a situation in which mathematics will be regarded with the respect which it so justly deserves.

[2] E. J. Russell, "*Principles of Crop Production*" in *The Scientific American Supplement* for July 8, 1916.

WHAT THE WAR COSTS.

On July 1 last, the first day of the present fiscal year, the war was costing:

$18,000,000,000 a year.
$50,000,000 a day.
$2,000,000 an hour.
$33,000 a minute.
$555.00 a second.

On July 1 next, according to latest estimates by the War Department, the war, for the twelve months, will have cost $31,000,000,000.

SUGGESTIONS CONCERNING SCIENCE NOTEBOOKS IN THE HIGH SCHOOL.

By John L. Dahl,
High School, Highland Park, Mich.

The science notebook in the high school is a perpetual problem to the teacher. The solution of the problem should not be neglected simply because the notebook may be considered a matter of little consequence. The science teacher must realize, and must make his pupils realize, that in high school science work there is a great opportunity for developing orderly and systematic habits. The notebook is an index of how well this process is carried out.

Science deals with natural laws which are in themselves inevitable in an orderly arrangement of the universe. If the teacher is slipshod in his methods as to apparatus, punctuality, notebook work, etc., his attitude will be reflected in each pupil. How often one can trace the mispronunciation of a word throughout life—and escape from this pronunciation with only the greatest difficulty—to the careless teacher, who helps form our habits during the really important and impressionable years of our youth!

The science notebook is a field in which one can emphasize orderliness at the very outset. The science teacher cannot, however, fill the role of the teacher of spelling, penmanship, and English, and that of a science teacher also, and do all the work well. If all these features are included, some phase or other of the work must be neglected. It were well, therefore, if the science departments in high schools generally, could cooperate with the English departments to have the literary elements of the science notebook looked over, and thus accomplish the twofold purpose of scientific accuracy and literary excellency.

In initiating a science class into the use of notebooks it is well to remember that the pupils are quite ignorant, as a rule, of habits of orderliness, of ability to interpret, of literary perfection, and many other desirable qualities which we would like to develop in them. (This statement is equally true of adults.) The following suggestions may have some value in making the teacher's work easier, the pupil's work more definite, and general results more productive of just those qualities without which high school science in general and notebooks in particular become valueless.

Laboratory manuals, as a rule, are very excellent in giving directions; but for the beginner they presuppose, too much, the

initiative which he lacks, for a careful record of results. The looseleaf direction sheet is, in the writer's judgment, preferable to the manual for this reason; if the loose sheet is used, care should be taken that directions be very definite.

Questions may advisedly be asked which are very carefully chosen, very definite in their thought, and frequently can be answered in monosyllables or in a very brief statement. Such definite questions would bring a well-defined thought to the mind of the pupil and a very definite answer, and would eliminate repetition of statement and obscurity of the written record when detached from the printed directions.

In discussing a difficult scientific problem with definite questions and monosyllabic answers as a basis, the manifold burden of spelling, literary composition, penmanship, and scientific accuracy would not be imposed upon the youthful investigator, nor would failure to comply with all the niceties of English composition remain a constant source of annoyance to the teacher who is obliged to review the papers. To find words habitually misspelled through carelessness on the part of the pupil is certainly not conducive to good nature on the part of the examiner; nor does poor penmanship produce psychologically beneficial results on the one upon whom the onus of looking over papers is placed. We may expect to have, therefore, by adopting the methods suggested for recording laboratory work, a very excellent way of lightening the work of both teacher and pupil. With the use of printed directions, correctly spelled words are constantly brought to the attention of the pupil; and if he sees them spelled correctly in the discussions which he is reading, he is not confronted with the demoralizing effect of a poorly constructed statement or sentence and a wretchedly written laboratory notebook. For this reason it seems advisable to have loose-leaf sheets with directions upon them which also have spaces for answers—in order to avoid repetition. The teacher examining such laboratory sheets, passed in periodically, will have his eye focused on the particular part of the sheet for the particular answer which he wishes to get. This arrangement will, therefore, save him a large amount of time to get the very specific results desired. The work of the examiner will be reduced a great deal for each paper, and one hundred papers may be looked over in a very much shorter period of time than when results are written in one hundred different ways, on one hundred different parts of the sheet.

Moreover, the pupil and the examiner will have the assurance that every answer has been carefully examined and that the results are therefore more scientifically reliable for future reference. It may safely be said that most teachers looking over laboratory notebooks cannot afford the time to read every single word written therein, and this neglect becomes a serious source of error, often vitiating laboratory notebooks as reliable reference books later on. In this connection we should not overlook the value of a definite place on the sheet for the pupil's name, the date, and such further data as the teacher desires for his own use and records. The printed laboratory sheet will, of course, establish a geographical location for all necessary data.

Now, a word about sketches in the science notebook. This is an extremely important phase of notebook work. Sketches have little value if they do not serve to familiarize the pupil with the object that he is studying. He may have ever so clear an idea of the subject, but it will not be of a lasting character. A carefully constructed sketch will serve to perpetuate impressions, thus having psychological value. Sketches also, if accurate, will reveal to the youthful investigator many obscure or concealed details. Therefore sketches have scientific value. But to be of any value at all they must be mathematically accurate. The aim, therefore, should be to attain accuracy even at the expense of so-called artistic appearance. Exact proportions in biological material should be emphasized. This can be done with the help of the rule, the compass, and other instruments of measurement. Distinct outlines are, of course, a positive necessity. Material should be as nearly perfect as possible and should be held in such a position as will reveal most of the scientific facts desired.

Great care should be taken with labeling. Often, more particularly in biological work, all necessary labels may be given on the laboratory sheet and the pupil asked in class room discussions to label his sketch, selecting from the list of labels given him, the proper ones, and indicating them on the sketch. This has the advantage of permitting the pupil to retain initiative, and giving him correctly spelled words to copy. He will be obliged to use his intelligence to select the right label and his powers of concentration to copy correctly. Also he will not fall into the error of omitting important parts; for, obviously, those parts must occur in a sketch before they can be labeled. Such sketches can then be taken up in class en masse by the teacher,

and each pupil can correct his own sketch for accurate labels. This will save time for all.

This procedure, besides being a time saver, is a further means of impressing the relation of parts and the names given them. Poor sketches, like misspelled words, ungrammatical statements, and illegible penmanship, are demoralizing and should not be permitted. Labels, for the sake of tidiness, may be put into a column and to the right of the sketch, being connected with their proper parts by dotted lines.

Copied sketches should not be entirely discouraged. Frequently such sketches are far more definite than an original sketch may be, and will economically supplement the original sketch. Like the plan of a house or the map of a geographical region, the copied sketch, when used advisedly, will fill a very important place in emphasizing desired details.

If anyone has the argument that this method of treating notebooks in high school science work is destructive of originality on the pupil's part, and is thus liable to the accusation of fostering a lack of initiative and hence efficiency on the part of the student, let him ask himself the questions implied by the discussion given thus far. Is efficiency promoted by devoting unlimited time and attention to the consideration of secondary details, by allowing the pupil to neglect definiteness, orderliness, literary accuracy, and neatness? Can the average teacher afford the time to look over with the greatest care every notebook handed in, and thus certify its validity for future reference? If so, is the teacher's time, devoted to mechanical detail at the expense of his own intellectual and pedagogical efficiency, well spent?

In a matter as vital as the science notebook let us adopt methods which will get desired results in a manner most economic for all concerned.

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Italy	25,000,000,000	7,000,000,000	28.0
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92. *Light in Relation to Tree Growth.* Price, 10 cents.
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Forest trees of the Pacific Slope. Price, 60 cents.

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210. *Seed Production of Western White Pine.* Price, 5 cents.
244. *Life History of Shortleaf Pine.* Price, 15 cents.
272. *The Southern Cypress.* Price, 20 cents.
299. *The Ashes: Their Characteristics and Management.* Price, 15 cents.
308. *Shortleaf Pine: Its Economic Importance and Forest Management.* Price, 15 cents.
316. *Willows: Their Growth, Use and Importance.* Price, 15 cents.
327. *The Spruce and Balsam Fir Trees of the Rocky Mountain Region.* Price, 20 cents.
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744. *The Preservative Treatment of Farm Timbers.* Price, 5 cents.

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Forest Service Bulletin.

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Forest Service Circular.

140. *What Forestry Has Done.* Price, 5 cents.

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154. *The Life History of Lodgepole Pine in the Rocky Mountains.* Price, 10 cents.
244. *Life History of Shortleaf Pine.* Price, 15 cents.

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SOME FAULTS IN PEDAGOGY.

By Ralph C. Hartsough,

Physics Instructor, Wichita High School, Kansas.

One of the outstanding faults of our present educational system is its artificiality. The major part of its content is unreal in its adaptableness, inside and more particularly without the schoolroom.

And one of the glaring faults of our present day pedagogy is its superficiality. We have many old time-worn premises which are false and always have been. It is just as imperative to reconstruct our pedagogy as it is our system of education. They should both be brought down to the realities of actual life as lived in the world outside the classroom.

Not only should conditions in our institutions of learning and actions be placed on a more real and practical plane but the student should be handled with the same regard and the same severity that he will find awaiting him after school days are over. We shall then not find him as a hothouse plant, withering before the new standards that are set for him, but, having weathered exactly similar blasts during his school life, he will stand strong and sure. Then instead of 80 per cent of our high school and college graduates experiencing the usual setback at their first initiation into the school of hard knocks, they will at once function and not fail.

The atmosphere of the classroom is very much different from that of business and social life. In school we still hold to many ancient ideas which not only work to the student's disadvantage during his school life but greatly handicap him after school days. The first of these ancient and old-fogy ideas is the putting of principle ahead of results. All through the grades, high school, and university, that false doctrine was drilled into me, and is still very much in evidence in most schools and colleges. Allow an illustration: If I knew to a nicety the most advanced theories and principles concerning banking and yet could not apply them and get results, the business world could not and would not use me. Accurate results come from knowing how, but knowing how is many many times so unproductive of right results. Correct results are the all important thing, and when we change our pedagogy and insist upon accurate thinking and accurate mathematics then our students will cease to be the inaccurate mental workers that they are. When a person is accurate and can get results, his confidence is a joy to look upon, and do not worry, he will weather successfully the modern world's demands upon him. Here is an illustration taken at random from many I might give: A class learns the principle that the volume of a gas at constant temperature is inversely proportional to the pressure. Yet when a problem is given using this principle we find these three classes of students: (1) Those who write the equation P_1V_1 equals P_2V_2 but are unable to go further. (2) Those who set up the equation and substitute correctly, yet on account of inaccurate mathematics do not attain the correct result. (3) Those who solve it correctly. After many trials on different principles, the per cent of students in these three classes is as follows: (1) 10 per cent, (2) 80 per cent, (3) 10 per cent. It is evident that these 80 per cent class two students are getting by with this class of work in our grade schools, high schools and colleges simply because it is customary to give half or more on correct principle. Emphasizing principle and not holding for correct results promotes carelessness and inaccuracy in our students. We misplace the emphasis and the all-important result is lost to sight.

Next, let us look into our scheme for passing or failing students. In general, we set too low a standard as the dividing line for passing and failing. Let us return to the banking illustration used above. Could a banker retain the services of an employe who would grade 75 per cent or even 85 per cent? No, he must

have the 90 to 100 per cent man. This is not only true in banking, but other business is the same. In the actual life of business and social affairs we demand accuracy and efficiency. There is no doubt that our students do not extend themselves to go beyond our expectations of them. We allow 70 per cent of subject mastered to pass and the majority hover around that point. In three schools with which I have intimate acquaintance the passing marks are 60, 70, and 75 per cent. The system of grading used in all three was an endeavor to say the student had grasped that per cent of the course. In these three schools the per cent of normal, superior and inferior students did not materially differ, but the standard of scholarship in the 75 per cent school was far ahead of the 60 per cent institution. If we would grade our students into inferior, normal, and superior, then divide the normal into inferior, normal and superior normal, it seems then we might set a higher standard for passing. The superior and superior normal should be the passing students while the inferior normal and inferior ones should repeat. Or on the basis of the per cent of subject mastered, students below 85 per cent should repeat.

We must rectify deeply and much in our pedagogy, as well as in our educational system, if we are to take front rank among the nations, for the oriental mind is fast overtaking us and will soon be rivaling our boasted superior intellects. We must produce graduates who will make good from the start so that the indictment of one of our big business managers will no longer be true. He said, "The majority of the graduates of our educational institutions lack confidence and are too inaccurate for my use." The utilitarian idea has steadily been gaining in our educational system and with it must come the sloughing off the curriculum of many subjects of doubtful usefulness.

We must introduce new subjects designed to help the student find himself. The crying need of our schools right now is an expert to discover the student's natural bent and assist the student in choosing aright his life work. This life, with its competition and specialization, has no place for the useless. Let everything in our system of education contribute to student's future enjoyment and worth as a citizen, and then our schools will serve the purpose which modern life demands of them.

PEDAGOGICAL EXPERIMENTS FROM THE BIOLOGICAL LABORATORY OF THE DeWITT CLINTON HIGH SCHOOL.

By Geo. W. Hunter, Ph. D.
DeWitt Clinton High School, New York City

The DeWitt Clinton High School is one of the largest schools in the United States, having at the present time about five thousand students within its doors; it is also one of the greatest college preparatory schools in the country. The Department of Biology and Hygiene has the unique privilege of administering to all of the students in the school. Every boy who receives a diploma must take one year of elementary biology, given during the first year of his course. In addition to this, he has instruction in hygiene one period each week throughout his school career. The department consists of twenty teachers, and the actual number of students registered for work last term was 4,185. Of this number, about two thousand take courses in elementary and advanced biology.

It is evident that if the teachers of biology are specialists, as they are, and are interested in the problems of teaching, as this series of articles will prove them to be, that this school gives a rather interesting opportunity for experimental work, not only in the content of the course, but also in the methods of teaching. Those of us who are familiar with the suggested lists of experiments given in a bibliography published in School Science and Mathematics, January, 1911, by W. L. Eikenberry, may remember some of the suggested experiments outlined for solution. Several of these experiments, concerning the method of study best adapted to classroom and to laboratory work with young pupils, have been attacked by the writer. A somewhat extensive article on this topic will shortly appear in one of the pedagogical magazines published in this country. This same article also takes up certain other phases of the problems of biology teaching, basing the solution of the problem upon the interests of the children in biological science material rather than methods of presentation of the subject.[1]

It is not my intention in this brief article to call attention to this piece of work, but instead to introduce a series of experiments which are at the present time in process of performance in this school. The first of the series was brought about in an

[1] "A Critical and Experimental Investigation of the Present Day Secondary School Methods of the Teaching of Biology in the United States," G. W. Hunter, Ph. D.

attempt at standardization of the teachers' work within the department.

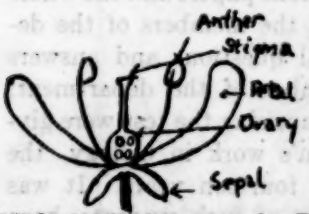
For several years it has been our custom to mark our final examinations in committee, each member of the committee being responsible for the marking of a question or group of questions on the papers. Owing to stress of work at examination time, and the fact that such methods of examination were not economical of the teachers' time, the members of the department voted to go back to the individual marking of examination questions. This has been done for the past two years, but in order to try out the reliability of the individual teacher in examination rating, the following experiment was proposed and started by Frank M. Wheat, a former member of the department. Owing to Mr. Wheat's promotion to the care of a school of his own, the experiment has been finished and written up by me:

We are all familiar with recent work on the unreliability of examinations as a test. In the work of Starch and Elliot[2] we find that individuals have graded mathematics papers with very great differences in individual marking, and in his recent book[3] Starch has given numerous examples of the individual unreliability of teachers' examination grades. In order to test the reliability of grading in our own department, the following mimeographed sheet was sent to each teacher in the department:

To Teachers of Biology:

Kindly find herewith a copy of ..... X's..... paper, giving questions and answers. Please grade the same and return to the Chairman tomorrow morning. Each question has a value of twenty (20); the parts of the question, as indicated. Do not sign your answer paper.

Q. 1. (a) Draw a sketch or diagram (5) and label five parts of the essential organs of the flower (5). (b) Give the use of any three parts labeled (6). (c) Tell very briefly how the seed and fruit are formed (4).

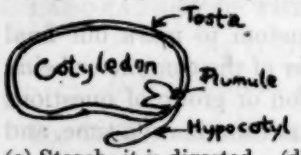


Ans. (a) (b) Petal attracts insect because of color. Anther produces pollen. Stigma is sticky, receives and holds pollen. (c) Two processes, pollination and fertilization, take place. The bee leaves the pollen on the stigma, causing fertilization; pollen grows down the pollen tube, and enters the ovule; the sperm cell fertilizes the egg cell. Then the ovule develops by increasing the number and kind of cells into a seed. The ovary changes, grows into a fruit and holds the seeds.

Q. 2. (a) Draw a seed (2); label parts of embryo (3). (b) Prove by experiment that the seed contains a nutrient (5); (c) What carbohydrate

[2]Starch, D., and Elliot, E. C., "Reliability of Grading Work in Mathematics," *School Review*, Chicago, April, 1913, Vol. 21, pp. 254, 259.
[3]*Educational Measurements*, D. Starch, McMillan, 1916.

is found in the bean seed (1)? Explain what is done with this when the seed grows (4). (d) Why does digestion occur (5)?

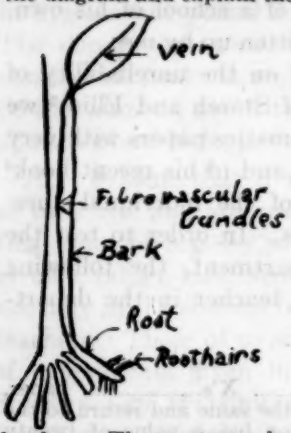


Ans. (a) (b) The seed contains a nutrient, starch. We know this because we can prove it by testing part of the seed, the cotyledon, in a test tube, adding water, shaking, boiling, cooling, adding iodine and getting a blue color which is the test that proves that starch is present. (c) Starch; it is digested. (d) Because an enzyme is present in the cotyledon of the bean.

Q. 3. Growing seedlings need air in order to grow. Show, in the form of an experiment, what part of the air they use (20).

Ans. I took some seeds and put them into a jar. I then sealed the jar tight. After several days, I looked at the seeds and noticed they had not grown. I then tested the air of the jar and found carbon dioxide present. I therefore conclude that plants use oxygen.

Q. 4. Make a diagram of a bean or a pea plant to show the path by which water from the soil reaches the leaves. Label all the parts of the diagram and explain the use of each part labeled (20).



Ans. (1) Root hairs, the organs that take up water.

(2) Root, lower part of plant.

(3) Bark, outer part of plant.

(4) Fibrovascular bundles, tubes through which water goes up stem.

(5) Veins, the places where water gets into the leaves.

Q. 5. (a) Give the use of seed (2), stem (2) and roots (2) of a plant to a plant; and to a man. Give examples. (Total 12 points.) (b) What does a plant take from its environment? (8)

Ans. (a) Seed is used to produce new plants, as a food for man; ex.: beans. Stem is passageway for food and holds up leaves, food for man; examples: leeks, lumber. The roots anchor, storage, take in water, food; examples: beet, carrot, medicine, root beer. (b) Air, through leaves; soil and water, through roots; light and temperature.

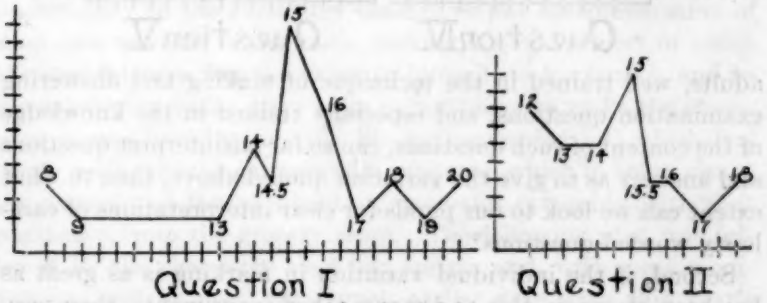
The above questions and answers were bona fide questions and answers taken at random from different papers and the whole made into a composite paper, so that the members of the department were confronted with actual questions and answers which were known to only one member of the department, Mr. Wheat. The several questions comprising the test were given to students during their first term's work in biology, the age of each student averaging about fourteen years. It was obvious that the biological information of such students, born and nurtured in a great city, would not be very great. The results of the ratings given by fourteen different teachers are extremely interesting, as they show a very great variation in grading. So far as I am aware, no previous experiment in grading

had been given in which the teacher had a definite weight for each question and part of a question graded.

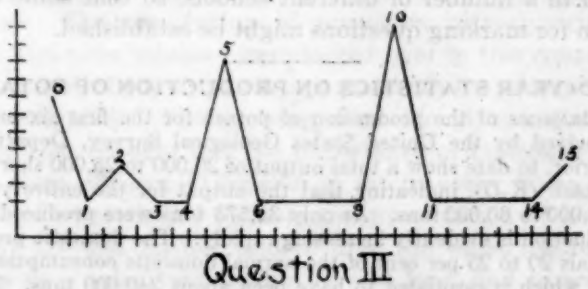
A COMPARISON OF TEACHERS' MARKS.

Teacher	Question I.	II.	III.	IV.	V.	Total
A	15	12	5	15	17	64
B	18	16	0	16	16	66
C	16	15	0	15	16	62
D	15	15	2	13	15	60
E	8	13	10	15	14	60
F	16	12	0	15	17	60
G	14	15	5	15	16	65
H	16	12	5	10	17	60
I	14	15.5	15	15	11	70.5
J	15	14	10	13	18	70
K	14.5	18	10	16	16	74.5
L	15	15	10	14	16	70
M	15	13	5	11	16	60
N	20	14	10	12	18	74

A glance at the preceding table shows an astonishing range in



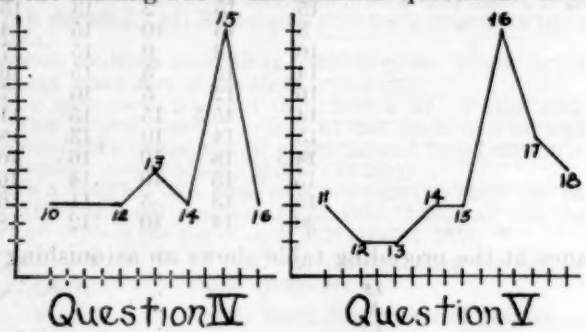
grades, even with a carefully worked out schedule of ratings already given the teacher; for example, Question 1: the range is from 8 to 20 points, the median of the curve being 15. The second question which, by the way, is a bad series, shows a flat curve ranging from 12 to 18 points. In the third question, owing to lack of rigidity on the part of some teachers or carelessness



as to the meaning of experimental form, the ratings range from zero to 15 points; in the fourth question, a slightly more uniform rating obtains, a smooth curve showing, the rating being from

10 to 16 points; in the fifth question, a fairly uniform curve is seen, the median at 16 points, in range from 11 to 18 points. The conclusions from the above series of ratings, if any, would appear to be as follows:

First, that much more care than is usually given should be placed in the making out of examination questions. If fourteen



adults, well trained in the technique of making and answering examination questions, and especially trained in the knowledge of the content of such questions, can so far misinterpret questions and answers as to give the variation quoted above, then to what extent can we look to our pupils for clear interpretations of carelessly worded questions?

Second, if the individual variation in marking is as great as has been shown in this and many other experiments, then very little reliability could be placed on examinations which are marked completely by individual teachers. It would seem that committee marking would be much more reliable than individually marked papers, if the pupil is to be judged by the mark.

Third, this experiment, or others of similar nature, should be tried in a number of different schools, so that some definite criterion for marking questions might be established.

MID-YEAR STATISTICS ON PRODUCTION OF POTASH.

The statistics of the production of potash for the first six months of 1918 received by the United States Geological Survey, Department of the Interior, to date show a total output of 20,000 to 25,000 short tons of pure potash (K_2O), indicating that the output for the entire year may reach 50,000 to 60,000 tons. As only 32,573 tons were produced in 1917 the production is evidently increasing rapidly. The domestic production now equals 20 to 25 per cent of the normal domestic consumption before the war, which is estimated to have been about 240,000 tons. The statistics for the first half of the year are not complete, for returns have not yet been received from a few large producers, and it is possible that the production in 1918 may exceed 60,000 tons, for reports made to the Survey indicate that a number of new enterprises may be put into operation during the second half of the year.

UTILIZING WASTE FAT FOR SOAP—A PROJECT FOR THE CHEMISTRY CLASS.

Experiments in soap making are included in most laboratory manuals. Performed in test tubes or small evaporating dishes, they are generally unsatisfactory. Saponification proceeds with difficulty or not at all, and only in rare instances does the student succeed in getting a product which he can recognize as soap, or with which he would be willing to wash even his hands. If the experiment is attempted on a larger scale, as directed in a few manuals, the expense for materials becomes excessive, and there is little spur to the student's interest to attempt the production of a larger amount of soap.

The present high cost of soap, the need for strict economy, and the utilization of all materials formerly wasted, furnishes an opportunity to the chemistry teacher to put the preparation of soap on a new and better basis, making it a real project in which the student may feel the value to himself, to his family, and to his country as well. Here is an opportunity to make the chemistry course function in daily life by converting fat, which formerly went into the garbage pail, into soap which in color, cleaning power, and lasting qualities, compares favorably with that purchased from the grocery store. The following plan was followed by the chemistry class last spring, and, with some modification, will be used at a much earlier date with this year's class.

The relation of chemistry to the war is a general topic whose ramifications extend in many directions, and which may be depended upon to stimulate and arouse the pupil's interest whenever this connection can be made. The study of explosives came uplogically after the class had made and studied nitric acid in the laboratory. The manufacture of guncotton, nitroglycerine and T. N. T. (tri-nitro toluene) were talked over in this connection, and the sources of supply of the raw materials for these products were investigated. The growing need for glycerine and its mounting cost brought out the importance of fat conservation and the more efficient utilization of fat in every home in the land. Pupils were asked to make an investigation at home, to see if any fat was wasted, and to urge the wider use of meat drippings as a substitute for butter and lard, and to see to it that any unused fat was carefully saved for use later in soap making.

The pupils were also asked to bring in recipes for soap making

which mothers or grandmothers had preserved from the earlier days when most families made their own soap. A number of these were collected and compared, as well as directions in various manuals and books. The following laboratory direction sheet was prepared on the basis of such a recipe, brought from the home of one of the pupils, after it had been tested and found to give satisfactory results.

Soap.

5 lb. Fat
1-2 lb. Borax
1 can Babbitt's Potash

Dissolve the potash and borax in three quarts of hot water, in an iron or enameled dish, and allow to cool. Melt the fat, and strain through two layers of cheesecloth, and allow to cool until pasty but not hard. Add the fat to the potash solution very slowly, a little at a time, and with stirring. After all the fat is in, stir slowly for ten or fifteen minutes, until the soap sets or becomes pasty. If the soap does not set after fifteen minutes of stirring, give it an occasional stir until it does become pasty. Pour out into a pan lined with waxed or oiled paper. When hard, cut into bars. If coloring matter is added, do so after all the fat is in and the stirring has proceeded for ten minutes. This soap sometimes floats on water. After the soap has hardened, it may be remelted by gentle heat and poured into moulds of various sizes and shapes. The soap should dry out for some weeks before it is used.

By the time the directions were settled, most pupils had accumulated at home from five to ten pounds of fat and set about the preparation of their first batch of soap. As might be expected, saponification took place at varying rates, and discouragement nearly overcame a few. One girl essayed a double batch and reported a complete failure. She was encouraged to keep on with the work, and the next day reported that on her return from school she had found her soap thoroughly set, of good appearance, and of such density as to float in water.

One member of the class, interested in Red Cross organization, gave a talk on soap making as a war economy, and passed on the directions for soap making to the other members. The same pupil followed up soap making after the close of school, and experimented with scents and dyes with such success that a sample of her product was placed on exhibit and will help this year's chemistry class in repeating the work and carrying it on still further. The school lunch room has been called upon to conserve all fat to the uttermost, and the accumulation is to be turned over to the class for conversion into soap. This work will be done by groups of pupils at the close of school or in free periods. The domestic science class is also interested and will further the work among its members who are not in the chemistry class.

THE METHOD OF THE SCIENTISTS.

By Morris Meister,
Teachers College, Columbia University, New York City.

Back in my undergraduate days we had a professor of physics whose delight it was to emphasize the logical development of his subject. As he told us again and again, the most important thing for us to get was first, physical concepts and second, scientific method—the method of the scientists. And so he spent the whole term in a course on electricity and magnetism, deriving the fundamental notions of unit of electricity, unit of current, unit of potential, and unit of resistance. He was minuteness itself in the detail with which he discussed what was definition, what was assumption, and what was experiment. In the laboratory he insisted on the most orderly arrangement of apparatus —on the extremes of accuracy—and any minute he was apt to interrupt, destroy our previous readings and start us over again because we had omitted some small step in his logical system. In a subject which has become as much a part of our lives as the very clothes we wear, this was his final examination, just one question, "Derive the fundamental quantitative relationships of Electricity and Magnetism."

I am not going to condemn his method nor his subject matter. Neither will I venture to estimate of what value the course has been to me; for I must confess I have now no means of judging. Just this do I want to make a point of, that three years later I had the good fortune to work in the same laboratory with this professor—I in a graduate course, he on a piece of his own research. I became rather interested in his problem and he was very willing to discuss it with me. He was working on a photometer that would eliminate as much as possible the eye in judging different shades and tints, and he had an idea. For days at a time he tried out the wildest of schemes. His table was a mess of apparatus, and his desk a mess of books and papers. He seldom took readings, and accuracy was the least of his concerns, though his instrument was a maze of scales and verniers. The most striking part about his work was his enthusiasm and the ingenious little tricks that he had of improvising apparatus that would short-circuit laborious method and make unnecessary great accuracy. His work, I hear, has been recognized as meritorious and quite a contribution to science.

I submit in rather detailed form this incident to raise and define the question of method as I want to discuss it in this paper.

There was certainly an inconsistency in the method of scientific research which my professor employed himself and the scientific method which he imposed upon us as students. I am safe, I am sure, in assuming that such an inconsistency is rather common with teachers of science, and also that any teacher or professor when attacked on pedagogical grounds will point at once with calmness and confidence to the "scientists" and show that he is getting his pupils to study by the "method of the scientists." Thus the problem arises: What is the method of the scientists?—and what is of paramount importance, this question is not merely one of academic interest. It is not that we want to catalogue the different methods of scientists or analyze them for common elements and so evolve a "method" that all scientists follow or should follow. But it is in reference to the teacher in the classroom that the question has its interest. I see involved in it the underlying principle of building the course of study in science, if not a solution to the problem of the curriculum as a whole.

If we adopt the idea that the experience of the human race is embodied in the sciences and that the method of life found most effective thus far is the method of science, then the curriculum as well as educational procedure in general centres itself around science and scientists. The latter terms are here used in their most comprehensive sense.

Educators and philosophers have always recognized this role of science; as witnessed by the work and writings of men like Bacon, Descartes, Locke, Kant, Mill, Spencer, Mach, and Poincare. Each of these men has analyzed the method of the scientist in his own way. Each of these men has built his metaphysics, his "grammar of science," and each in his day has affected or is affecting the problem of education in accordance with his analysis. And around each of these analyses there usually grow up small groups of professors who idolize that particular type of research or who throw all work in science into their particular mold. One is struck in pursuing the literature in the method of science to find the definiteness of the steps in scientific thinking and discovery. It is this definiteness against which science teaching is now struggling. Inductive teaching, whether it be Bacon's or Mill's or Locke's, is not satisfying the demands of the world—neither is the deduction of Descartes nor the induction-deduction of Mach and Poincare. The results are poor, not only in the classroom but in the research laboratory as well.

When I express this dissatisfaction with the metaphysical analyses of the method of science it is not that I dare to discredit them nor that I do not see the value of these works as works. These ideas become insidious only when we attempt to graft them on immature minds. My professor of science, after a lifetime of research and study, comes to a real appreciation of science. He can see with Newton the whole universe in terms of F = ma. This symbol takes on a wealth of meaning and it gives him distinct pleasure to use such a short hand for his ideas. He cannot, however, resist the desire to teach his terminology and so he imposes in the very first lesson this symbol on his pupil. What is more, he grows impatient if the latter holds the formula in contempt, doesn't remember, cannot use it and does not appreciate it. He assumes a holy attitude—looks down commiseratingly on the poor ignorant soul who is not made of the clay of science, who has no reasoning faculty and he grows intolerant at the desecration of the holy things of science by so lowly a mind. The great distinction that we lose sight of is that a metaphysical analysis of the method of science, such as Poincare's for example, treats of the *work* of the scientists, while any aid which the teacher can get will come from watching the scientists *at work*.

The science teacher may be pardoned who, after perusing Prof. Pearson's "Grammar of Science," is still left perplexed about the "reality of things," "reason behind nature," "cause and effect," "space and time," and who cannot, as the director of twenty-five young lives in the realm of science, see scientific method along such lines.

And so to return to the problem, we shall in a sense attempt to analyze the method of the scientist and not of science. Who are the scientists? For the teacher they can be but the men who have given us our present stage of knowledge and civilization. Because he takes no stand on the various schools of metaphysicians he can disregard the distinction between pure scientist, practical scientist and inventor. Here is his list, which no one can deny at least includes the scientist, whomever else it may include: Archimedes, Galileo, Newton, Darwin, Kelvin, Pasteur, Davy, Faraday, Maxwell, Helmholz, Kirchoff, Mendeleef, Edison, Meyer, Roentgen, Priestly, Bunsen, Cavendish, Berzelius, Charles, Gay-Lussac, Lavoissier, Ramsay, Scheele, Van Helmont, Morse, Curie, Bertholet, Rumford, Boyle, Avogadro, Black, Dewar, Graham, Ostwald, Rutherford, Thomp-

son, Bessemer, Franklin. I might add that this list is in no way exhaustive; it merely represents the lives that I have in some measure been able to investigate.

It does not take long in such an investigation to be struck with one fact. Whether it be the abstract thinker Newton or the gross materialist Edison, each pursues his work with an enthusiasm so intense that there is nothing to which his work is subordinate. Wealth, happiness, friendship, life and limb, are all placed on the altar of science. Very few of these men had their work chosen for them by parents or friends; in fact, in nearly every case they had to oppose efforts to place them in certain definite positions in life. Something drew these men on which alone can account for their spirit of enthusiasm and this was not the "poetry of logic." Newton under the apple tree, Galileo at church watching the swinging lamps, Archimedes and King Hiero's crown, Pasteur and the silkworm disease in France, Davy and the coal mine explosions, Hooke and Huyghens and their need for a timepiece, Halley and the meteors, Faraday and Arago's rotating disc, Roentgen and his fortuitously developed photograph, Cavendish and his burning hydrogen, Galvani and his frog, Edison and the present submarine crisis—to me all this presents one picture—a scientist perplexed, a scientist seeking a solution, a scientist with a problem on his hands. It is that which explains his enthusiasm. A vital, pressing need forced itself upon his attention, by accident or as an outgrowth of some previous problem, and because of its vital nature gripped the man, not letting him rest.

The more we go into the details of things which occupied the minds of these great men the more we are led to the conclusion that life to them was a series of doubts; so much so that I am ready to say that the sine qua non of scientific method is perplexity.

Professor Mann, in his chapters on the Pedigree and Method of Physics, goes to the extent of saying that these pressing needs have kept pace with the development of industry and that science and its method are the outgrowths of industry. In tracing this growth he notes first, that "the process by which it was accomplished was this: some human need, desire, longing or aspiration made itself felt, whereby a problem was defined—a problem that would not lie down and keep quiet until the need that called it into existence was satisfied." Second, that "the solution of one problem reacted to stimulate new needs and desires;

and these in turn defined new, more refined, and more difficult problems." Third, that "the success of this upward movement of industry and commerce was due to the fact that they were able to 'deliver the goods' that were needed to satisfy the human desires that called them into being." And fourth, that "the discoveries achieved by this method of solving problems were so concrete, so impelling, so undeniable that even the infallible church had to succumb. . . . When large bodies of men had thus become accustomed to thinking in this way, the time was ripe for the extension of the method to the solution of more general and abstract problems. Then it was that modern science proper began."

In a like manner Dewey treats this same matter of perplexity as the first ingredient of the scientists' method from a different angle. "Wonder," he says, "is not only the originator, but it is the continuer of science. Wonder is the emotional outgoing of the mind toward the universe. It is the sole spring which can take a man beyond his subjective states and put him into that active relation to the world which is the sole condition of getting at its meaning. But it is no less true that wonder is the cause of all growth, of all increase of knowledge."

Now, whether we adopt Mann's extremely materialistic notions of the kind of needs which urge scientists on, or Dewey's more altruistic notion, or as Mann actually suggests consider Industry the father and Wonder the mother of modern science, is to the teacher really immaterial. The emotions are the prime movers of the child—we cannot say, whenever we are ready and in our own most suitable way, "Now, children, you must engage in scientific thought." Newton couldn't do it, Galileo couldn't do it, Faraday, Darwin, Kelvin, Maxwell, Archimedes, Pasteur, Priestly, Rumford, Boyle and all the rest couldn't and didn't do it.

I have outlined and discussed what is believed to be the first "step" in a scientist's work; but it would be useless I feel (for practical pedagogical purposes) to carry the process further as a series of steps; not because these steps are not followed, but because they are followed automatically and unconsciously. There is a period or stage in the scientist's work when his difficulty or perplexity is not clearly defined, and then he does consciously apply criticism and experimentation. Thus Davy's mental machinery did not begin to function properly along scientific lines until he had examined the kinds of gases that caused explosions in coal mines and had seen the futility of ven-

tilation. It was a clear definition of the difficulty that set him to working on a lamp which would give light without bringing the explosive mixture to its kindling point. And so it may be of value to note this second "step" in teaching; but to carry it any further as a program would be creating another "grammar of science." And yet what is it that the scientist does unconsciously or automatically? In the words of Tyndal, "from a starting point furnished by his own research or those of others, the investigator succeeds by combining intuition and verification. He ponders the knowledge he possesses and tries to push it further; he guesses and checks his guesses; he conjectures and confirms or explodes his conjectures. These guesses and conjectures are by no means leaps in the dark; for knowledge once gained casts a faint light beyond its own immediate boundaries." This stage of the scientist's work can almost be termed the art of science. The genius of the man is at full play—his intuition, his knowledge, his very being is concentrated on the difficulty before him; and inspiration plays as great a part with him as it does with the poet.

Count Rumford, for example, in carrying on tests on the rate of cooling of certain bodies, prepared two bright metallic vessels which he filled with hot water and placed in a large quiet room. As he progressed, it suggested itself to him to cover one with Irish linen and note the result. He next tried glass vessels, both with thick and with thin walls. He coated one vessel with a layer of glue and then added several layers more. He painted some black and some white, etc. His different tests were not entirely at random, and yet he couldn't say what it was that led him to the right path. The laws of radiation were his inspiration. Again, let us watch Faraday at work. He needs an electric machine, and so he inverts a four-legged stool to serve as a stand. He takes a glass bottle for his cylinder, fastens a cork into the mouth and a bung in the other end. Into the cork he inserts a handle for rotating the bottle, and in the centre of the bung a wooden pivot on which to turn; while with some stout wire he makes crutches on two of the legs of the stool for the axle to work on. The silk rubber he holds in his hand and a Japanned tea-canister resting on a glass tumbler forms the conductor, while the collector was the head of a toasting fork. Or again, let us watch Jacques Loeb at work. There is something uncanny about the way he adjusts the conditions of his experiments to bring results. Why choose a solution of salt in which

to throw his pulsating animal forms? Salt alone gave him his result. Now he cuts a cube from a cell and it grows tentacles. Now he cuts a new mouth in an organism and observes the struggle between new and old, so that part of the body is led to involuntary suicide. He seems to "sense" the truth. This aspect of the scientific investigator had so impressed Priestly that he himself said: "Many of my most startling discoveries were the result of chance operations—not of themes worked out and applied."

The same trait can be found (and had I the space I could multiply the instances indefinitely) in nearly every scientist. The glimpse of truth comes not as the hard conclusion of logical steps but evolves almost accidentally from almost hundreds of tests and trials ingeniously devised and artistically controlled. The longing, the desire, which furnishes the motive to keep the scientist at work, somehow induces hypotheses, trial solutions and tricks to force nature to give up its secret. What is more, this is true not only with men of science but with men in the lowliest walks of life. It is the natural way in which our brains act; and is it therefore reasonable to imagine that children will become scientific thinkers if we simply put them through the motions called for by the steps in the formula? We must induce in them motives in some way similar to those which impel real scientists doing real investigation.

I tried recently to get a class in science to re-live the motives and experiences of Davy in the work which led to the invention of his lamp. I pictured the conditions in his day—how England was repeatedly shocked by the great explosions in the coal mines; the destruction of life and property, the misery and destitution. I showed how the development in the iron trade and of the steam engine was making more and more demand upon the coal supply; and how the intensive working of the mines extended and aggravated the evil. In the old days when the pits were shallow, fire damp, although not unheard-of, was little dreaded and explosions were rare; but as the pits became deeper and the ways more extended the fire damp accumulated. I pictured a miner crawling along a dark, narrow crevice, groping his way with a candle, and then, before he knew it, the terrible roar of the explosion caused by the candle in his hand. Things went from bad to worse, until the companies even forced the newspapers not to print news of the explosions for fear of arousing public opinion against them. How could the mines be cleared of fire

damp? (the class certainly saw the problem). Various means were tried by different men, such as ventilating schemes, spark wheels, flushing with chlorine, airtight lamps, etc.; and I led the class to see why each failed. The demon of the mine grew more and more formidable and mechanical science seemed to have spent itself when Davy was called upon. He visited the mines, brought back samples of fire damp and commenced work. He soon found that fire damp needed a high temperature to explode it and that the flame formed by the union of air and fire damp would not pass through tubes of certain diameter. Glass tubes were tried but were found to be not as good as metal tubes, and wire sieves were very good. He tried an electric lamp, but that failed, and so he finally decided upon a lamp that would use the very explosive mixture to give the needed light. He made eleven different lamps, which at last determined the proper one, and he tried it out first in an explosive mixture on the surface and then in a mine. "It is impossible for me to express my feelings," he says, "at the time when I first suspended the lamp in a mine and saw it red hot. I said to those around me, 'We have at last subdued the monster.' "

The above is only one of the many illustrations of how a project of a scientist can be made a project in the classroom. It shows as well the genius of the man at play in its total disregard of logical steps. In the words of Prof. Mann, "While a physicist is laboring over a real scientific research, he finds it difficult, if not impossible, to guide his thinking according to any logical formula. But when he has solved his problem, he describes the process by telling how he first sensed an inconsistency or a gap in a system of ideas which were concrete to him; how he then, by search for related ideas and facts, or by both, succeeded in defining the problem sharply; how he formed a plan of action or theory to serve as a tentative solution of the problem; and finally, how he deduced the consequences of his theory and tested them by experiment. This is excellent form for telling about his investigation after it is done. But it is clear enough that he never laid out his investigation in advance in any such sharply defined steps. During the process of the solution he was constantly associating, dissociating and ordering ideas, making inductions, deductions and verifications; and, in short, thinking as we all think by processes that are too complex to be analyzed."

Our analysis of the scientist at work has thus far brought out:

(1) That he begins in a state of perplexity.

(2) That he works with an intense enthusiasm because this perplexity is the result of a real, pressing, vital difficulty.

(3) Once the difficulty is clearly defined, his enthusiasm carries him to a solution by a process which is automatic but which can be described as:

(a) A process of rapid suggestion, supposition, guess, hypothesis or theory—pending further evidence.

(b) "Reasoning out" the implications of each suggestion.

(c) Deliberately and cleverly arranging conditions in accord with the requirements of any of the suggestions to see what results occur and to weed out the false suggestions.

The superiority of such an analysis over one which sets up certain definite steps lies in its implications for the teacher. The whole of life can be thought of as a series of problems or hurdles, the series progressing from the simple needs of childhood to the intellectual needs of the educated adult. This line of growth cannot be short-circuited, for each step is prerequisite for each succeeding one. The teacher's task becomes simple and yet difficult; simple, because he must merely commence the process by so controlling the situation that a need or problem will arise for the child—the rest, within certain limits is automatic, and yet difficult, because these limits are the capacities of the child; and to properly gauge these and take them into account requires teaching ability of a high order.

On this basis we can now see clearly the distinction between pure scientist, practical scientist and inventor. Was the method of Newton, Kelvin or Maxwell any different from that of Priestly or Rumford or from that of Edison or Morse? Our analysis shows that there was no difference in method, and our conception of life as a progressive series of problems involving the above analysis in their solution accounts for the difference in results. Up to eighteen years of age Newton and Maxwell were Edisons; up to thirty they were Priestlys and Rumfords; and in their prime they were themselves. What I wish to say is that with the changing character of their "perplexities" we have the changing of results; and the labors of their later years were made possible by those of their youth. We usually think of Newton as the abstract thinker and philosopher whose problems were those of the universe. Newton as a boy spent his time making model windmills, water clocks, self-propelled carriages, kites, sun-dials and reflecting telescopes. He would delight in cal-

culating the velocity of the wind by jumping against it and with it. He was a little Edison at work. These projects gradually developed till he found himself pondering the question of gravitation. That his method and attitude were always the same is illustrated by these words from his own pen: "I do not know what I may appear to the world, but to myself I seem to have been but a boy playing on the seashore and diverting myself in now and then finding a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me." The same was true of Maxwell as a boy, of Kelvin and all the rest of the abstract school. The fact that they outgrew these early stages makes them the great scientists that they were. Men like Rumford outgrew the early inventive stage but could not or would not be "perplexed" by anything the solution of which would not be of great material value to the human race. Rumford, for example, spent a good part of his life in trying to devise a method of using up the unused material in the smoke which habitually hung over London; and spent a good part of his fortune on his dream of "forming, by subscription, in the metropolis of the British Empire, a public institute for diffusing knowledge and facilitating the general introduction of useful mechanical inventions and for teaching by courses of philosophical lectures and experiments the application of science to the common purposes of life."

In thus calling Newton a scientist of the first water, Rumford a scientist of the second, and Edison one of the third, I wish to make it clear that it is not their contributions to the world's welfare that I am attempting to estimate. It is merely distinguishing three types of men who, though employing similar methods of work, arrived at different results.

Now I said in the very beginning that it is in reference to the teacher in the classroom that this question of method gains its interest and importance. A scientist at work is but a human being at work—a human being who has accomplished something. What is more, adding up the accomplishments of these men we have what we are trying to put into our curriculum. Now shall we take the results of these men, predigest them, and feed them to our children, or shall we learn from the method that these results were obtained the way to hand it over to the child? The scientists have explored unknown regions and have charted the ways. The curriculum is the map which they have left us; but each child must in a measure live through the ex-

periences of the pioneers and reconstruct for himself their map. Thus we have the justification of the project method of study and especially for the project method of studying the sciences. The lives of the scientists are lives full of projects, which projects should now become the projects of the schoolroom.

The great evils of the science teaching of today are due chiefly to the adherence of science teachers to a false analysis of the method of the scientists. The formal logical steps of Bacon or Mill or some of the other metaphysicians attack the problem from the wrong end, as far as the educator is concerned. It is Dewey's analysis of thought which I have attempted to apply to the work of the scientists that I believe will solve the problem of science teaching.

HARDSHIPS EXPERIENCED BY RASMUSSEN'S SECOND THULE EXPEDITION.

The expedition, composed of Knud Rasmussen, leader; Dr. Thorild Wulff, Swedish botanist and ethnologist; and Lauge Koch, geologist and cartographer, left its base in North Star Bay in April, 1917, and proceeded successfully as far as St. George's Bay (82° N.). Here game failed them, so that, with the exception of a few hares, and a seal or two, they killed no food at all. Unable to proceed beyond De Long's Fiord, about a degree farther north, they turned homeward at that place. One of the Eskimos, Hendrik Olsen, who distinguished himself in the service of Mylius Erichsen's East Greenland Expedition several years ago, was killed and eaten by wolves while out hunting game, just before the party mounted the ice cap to start back to North Star Bay.

The journey across the ice cap was accomplished in the face of almost incredible difficulties. The party ate the dogs one after another; just after the last dog had been eaten they reached Cape Agassiz, near Humboldt Glacier, on the west coast. They were all weak, exhausted, and starving. Knud Rasmussen and one Eskimo started immediately for Etah to obtain succor for the others, who were to follow along more slowly, living on the game that they hoped to kill, until help reached them.

Unfortunately they could find neither hare nor caribou, and in a few days Dr. Wulff became so weak that he could go no farther. After writing brief messages to his family and dictating to Koch a summary of his observations of the flora of the lands immediately south of the Humboldt Glacier, he bade his companions farewell and resigned himself to his fate. Koch, whose strength was fast waning and who was too weak to encourage Wulff to proceed or to help him in any way, continued slowly with the two Eskimos on the weary way toward Etah.

Dr. Wulff had continued his scientific labors to the last. According to the letters, he accomplished a splendid piece of work, both in botany and zoology. He had continued his observations until he could go no farther and died, as a brave man would, in the field of his endeavors.

Koch also accomplished satisfactory work. He mapped the entire coast along which he traveled, including several new fiords that he discovered, and collected Silurian and Cambrian fossils far north. According to a letter from Upernivik, dated January 23, 1918, he had not then fully recovered from the effects of his exhaustion and starvation.—[*Geographical Review.*

Why One Should Attend the November 1918, Meeting of the Central Association of Science and Mathematics Teachers.

THESE are times when those of us who are "over here" are pushing harder on all of the home things to make up for those who are "over there," and we are coming to be glad for and to be proud of the very real part we are having in this citizens' war.

In a frank and fraternal way let me suggest to you some reasons why you should make an especial effort to attend the Eighteenth Annual Meeting of the Central Association of Science and Mathematics Teachers which is to be held at the University of Chicago on the Friday and Saturday following Thanksgiving, November 29 and 30. Candidly, most of you have put your heart's blood for years into building up the Association, and you will doubtless think of arguments which I have not. Just add them all to my simple statements and, not only come to the meeting yourself, but be a missionary to bring with you every one of your colleagues whether members or not.

In the first place the Association needs you and your strong influence at this time more than it ever has. And in the second —pardon me—you need the Association. In spite of the high cost of living and traveling we must continue the usefulness of our science and mathematics fraternity. Indeed we must go forward. Since so many of our members are "over seas" or in camps, the Association has to depend upon you loyal, faithful member, to rally even more strongly to its support, and to enlist new members. Teachers will say that they are so pressed for time, and the demands upon their salary are so heavy, that they cannot join, much as they wish to. They cannot afford not to be members. You cannot afford not to attend the Annual Meeting. Why? Let us consider the matter together.

One result of the war will be a shifting of our educational programs, standards and ideals. The Executive Committee of the Association feels that it will be justified in holding the conference this year upon one basis only; that of bringing before our members the problems which are arising in science and mathematics teaching and giving you the chance to discuss them and compare your experiences and constructive plans with those of your fellows.

Do you realize what an opportunity is ours just now? Never in all history have teachers had such a prospect for reconstruction and service in their profession. We wish for more recognition from society and adequate salaries. But we know that a far greater reward to us is the deep satisfaction which comes through having a share in the construction of pioneer things in education. Some of our country's men and women are bound to become the leaders in this vital hour. Will you be one of these creators? Will you commence now and will you bring to the Annual Meeting all of your ideas and enthusiasm?

About the first of November you will receive the Program of the Meeting. We hope you will read between the lines and realize how the addresses for the General Session and the programs for the Section Conferences are all built around the central theme—"The Educational Demands of an Awakened Democracy."

Let me call your attention in the briefest manner to a few things in the way of illustration. The speaker upon the central theme itself is to be Andrew McLaughlin, Head Professor of History in the University of Chicago. He went to England recently at the invitation of that Government as spokesman for our country. Everyone who has heard him since his return declares he has brought back to the United States a wonderful message and that he is a most attractive and forceful speaker. By the way, we are urging our members to make a sacrifice and attend the Annual Meeting. Do not forget that our speakers and writers of papers are making an even greater sacrifice. Prof. McLaughlin is one who is coming to us in the midst of an already overcrowded schedule.

The other Friday forenoon speaker is A. Barthéleme, Consul for France. He will address us upon "Progressive Science and Mathematics Courses and Teaching in France." The Consul is a graduate of the University of Paris. He has been in editorial work, was one of the representatives from France at the World's Fair in Chicago and was Consul to Great Britain before coming to the United States.

In the evening we shall have a cafeteria dinner together at the Quadrangle Club. While about the tables the Chairman of the Committee on Science and Mathematics in the High School of Tomorrow will give his report. This will be followed by an informal discussion. When through we shall adjourn to a social hour. There we shall have the great privilege of coming into close relationship with another one of the very busy men and winners of the war, Dr. Steiglitz, Head Professor of Chemistry in the University of Chicago, who has been devoting his research and that of his whole department, which has remained intact for this purpose, to the making of war gases. He will give a very brief shop talk on "Gas Warfare" and then permit us to put to him all the questions we care to. This in itself is a rare opportunity for members of the Central Association.

An important feature of each Section program is the report by its member of the Committee on Science and Mathematics in the High School of Tomorrow. He will give the result of his study and open the discussion. Here again you will find just the material you will wish to use in your own constructive problems and personal development and leadership.

It is not possible to present, even in outline, the exceedingly attractive program which the Sections have prepared. Your Executive Committee has marvelled that men and women of such reputation could take time from their overburdened lives to come to us. It simply means that they realize what a force our Association is in building up the boys and girls of the Central States. Here is another reason why we should support the meeting and magnify its service to the science and mathematics teachers of our acquaintance.

Just a word as I close abruptly. Do you know how much it means to have fellowship with the teachers of your department? Have you felt the fraternal warmth which those of us who get together have for one another? Really this is one of the fine rewards for being a teacher. You will not find anywhere stronger, more sincere and more helpful friends. Just come open hearted, and with the determination to take an active part in the meeting, and learn for yourself how good this will be for you.

And be sure and bring all of the Science and Mathematics teachers of your territory with you. This is your privilege.

Plan today how you will win them. It will take thought, time and work. But so does everything worth while.

Let us one and all have a part in working out "The educational demands of an awakened democracy." What a joy it will be to look back and realize that we contributed in this vital way to the final establishment of liberty and its blessings.

Yours for the Central Association,

HARRY D. ABELLS,
President.

ORGANIZATIONS UNITE FOR SERVICE.

To carry unitedly to the men in France the welfare services which during the past year have built up the morale of General Pershing's army, the seven relief organizations of the United States will conduct from November 11th to 18th the United War Work Campaign for $170,500,000. The agencies cooperating are the Young Men's Christian Association, the Young Women's Christian Association, the National Catholic War Council, the Jewish Welfare Board, the War Camp Community Service, the American Library Association and the Salvation Army. In France these several organizations have worked in closest unity and without duplication of effort among the enlisted men of the American army and navy and their allies. In their common appeal for funds, an opportunity is given for similar joint action on this side of the Atlantic. To every boy in uniform each organization through its representatives over there stretches out its home friendliness. Its clubroom is his church, his college, his library and the biggest reminder he has of home. If he is studying now for after the war, there are night classes and lectures on modern history and current events. Even into the front line trench the welfare agencies have carried their class-rooms. In giving to its activities during the war the public is already starting to meet the after-war problems.

The Young Men's Christian Association which is asking $100,000,000 for its war work, is serving no less than three million American soldiers and sailors in Europe and in the training camps at home. It has between five and six hundred huts in this country and a greater and growing number on the other side. It is keeping a bit of home even at the trenches and under the fire of the enemy. The Y. M. C. A. hut at the front is the soldier's club, his church, his college. It is open to all denominations for service, from the early mass of the Roman Catholic, to the later service of the Protestant clergyman and the Jewish Rabbi, and the song service of the Salvation Army. It is used for musical and theatrical entertainments by the most famous musicians, actors and actresses of the world. It is a place of study and lectures for the boy who would study French or other subjects to be turned to account in after-war days; it is the quiet place where the soldier reads or writes his letters home.

The Young Women's Christian Association, asking for $15,000,000 has gone into the war and into the war industries with the women and girls called to new and perilous work. It has cooperated with the government in the proper housing and care of the women munition makers in this country and has provided recreation centers at all of the twenty-one cantonments. It has established similar centers at munition plants in France and has been so successful in providing necessary rest and recreation that the English government has asked the help of the American Y. W. C. A. in work of that character in England. It has club centers in Russia at Petrograd, Moscow, and Samara, and cooyerated wth the Y. M. C. A. during the summer in an agricultural exhibit on a boat that

plied up and down the Volga river. It has about one hundred hostess houses—"a bit of home within the camp"—erected at military camps at the requests of the commanders, and a number more are authorized and being built. It is doing work among the colored girls affected by war conditions, and among the foreign-born women whose men have gone to war.

The National Catholic War Council including the Knights of Columbus, asks $30,000,000. The Knights of Columbus have erected club houses at the points of embarkation in this country and embarkation in France, and have secretaries assigned to permanent duty aboard transports plying between this country and European ports. There is a headquarters building in Paris and permanent club houses throughout France and in London. A fleet of motor trucks follows the rapidly advancing armies to provide our soldiers with "service under fire." These trucks carry chocolate, writing material, soap and towels, and other articles.

The Jewish Welfare Board, which will receive a $3,500,000 share in the United War Work Campaign, officially represents all national Jewish organizations in building up the morale of more than one hundred thousand Jewish men in the army and navy. It has sent its trained workers into the camps and naval training stations. It has erected clubrooms to which soldiers irrespective of race can go for rest or for entertainment, where there are libraries with English, Yiddish, and Hebrew books, where religious services on Friday evenings and holidays are open to any man who wishes to attend. In the towns near the camps, community centers furnish the soldiers with social rooms and sleeping quarters. Jewish chaplains are serving with the army overseas and in the navy. Welfare workers are aiding the families left at home and among the men in the ranks are performing personal services, distributing gifts, and keeping up the boy's contact with his home.

The Library War Service of the American Library Association which is asking for $3,500,000 has sent overseas during the past year more than a million books for the men of the fighting forces. It supplies a book for the man when he wants to read and the kind of a book that he wants. It gives its service quickly and directly to the army and furnishes to the soldier who is preparing for after the war the technical books that he needs for his study. In the huts and canteens of all the welfare organizations a branch library has been established at which the soldier or sailor can pick up in his hour off duty the novel or magazine that suits his fancy. There is a deck library on every transport, and on many of the war ships and government cargo ships. In every ward of every military hospital a shelf of books is near the hand of the convalescent soldier. The boo from the home library, the magazine, the new educational or technical volume bought with money from the public, will circulate through the Association to every man in every branch of service.

The War Camp Community Service which is asking $15,000,000 is a nation-wide movement for hospitality keyed to harmonize with the training camp program of the War and Navy Departments. It has a definite, ordered program, supplemented by resources of the folks back home. It counteracts the red light lure with the greater attraction of wholesome recreation and speeds the man in khaki or blue on his overseas way with a keener enthusiasm to fight for a country in which he leaves no bitter, regretful memories. The War Department Commission on Training Camp Activities was appointed by Secretary Baker in April, 1917. The Navy Department Commission of Training Camp Activities was established by Secretary Daniels at the same time. These Commissions called on the Playground and Recreation Association of America

which had had years of experience in this sort of thing, to carry on the work in the communities outside and adjoining the camps under the official name of the War Camp Community Service.

The Salvation Army's request for its work at home and abroad is $3,500,000. As near the trenches as relief work can be carried, the Salvation Army "hutment" is open, and a woman officer ready to serve hot food to the men under fire. A cook stove with an oven that can bake is certain to be part of the equipment of the little Salvation Army house. In front of it, "lassies" with baskets of food have stood under fire in order to give a hot cup of coffee to the men who are bringing up the ammunition. Truck loads of pies and doughnuts start daily from the bases to the extreme ends of the lines. The women officers have mended the clothing and darned the stockings of the soldiers who come to the hutment for recreation. In this country, the Salvation Army maintains hotels near the military and naval bases, and in their clubrooms entertainments fill the soldier's leisure time. Church services are held on Sundays.

CALIFORNIA COAST FOGS.

The importance of fog in navigation along the California coast is strikingly evidenced by the following fact. The Marine Exchange of the San Francisco Chamber of Commerce was asked what proportion of the shipwrecks which occur along the coast of California are due to fog. The answer was, "All of them." High winds and violent storms are rare. Fogs are the greatest danger to navigation. They are the chief contributory cause of the majority of marine disasters. Recent extensions and improvements of the fog-reporting service of the Weather Bureau have made possible a more detailed and more accurate study of fog conditions than could be made until now. Mr. Andrew H. Palmer, of the U. S. Weather Bureau at San Francisco has prepared some new statistical tables and has briefly discussed the data ("Fog Along the California Coast," *Monthly Weather Rev.*, Vol. 45, 1917, pp. 496-499).

Two types of fog have long been recognized on the California coast, summer fogs and winter fogs. In summer a fairly persistent fog bank hangs alongshore, extending seaward about fifty miles. The average vertical thickness is 1,500 feet. A vertical extent of 2,000 feet is rarely exceeded. During the summer months the excessive heating of the land causes an indraft of air from the ocean to the west. The inflowing wind reaches velocities of twenty-five or thirty miles an hour on summer afternoons near the Golden Gate. The westerly wind carries the fog onto the land, but it is usually dissolved, or becomes "high fog" or cloud before it penetrates far inland. These summer fogs seem to be due chiefly to the mixture of air masses which differ in temperature and in relative humidity. The temperature of the mixture is below the dew point, and condensation results. Along the coast there furthermore is an upwelling of cold water, similar, it may be noted, to the conditions off the coasts of northern Chile and of Peru, of northwestern Africa, and of the Somali coast. During the summer, with generally light winds, the air over this cold water is also cold and nearly saturated. The prevailing westerly winds, reinforced by the indraft towards the hot land, blow across this cold water. These westerly winds are themselves nearly saturated but are slightly warmer than the cold air with which they mix. The mixture of these two air masses, both not far from their dew points, produces the condensation. These fogs seldom produce measurable precipitation, but are of great benefit to vegetation, as, for example, to the redwoods, which are limited to a narrow coastal strip in the fog region and never extend

more than thirty miles inland. This summer type of fog sometimes occurs in winter but is rare then because the air is cooler than the water.

Winter fogs are of land origin. They are radiation fogs. They occur in all parts of California and occasionally move seaward, without going far offshore. They are thin (100-200 feet vertical extent); occur under weak gradients; and form at night. "Tule fog" is the local name for these winter fogs in California, because they are so frequent over swamps and marshes filled with tule (Mexican bulrush). Tule fogs last until they are "burned off" by the sun or are displaced by the wind.—[R. DeC. Ward in *Geographical Review.*

HONEY PRODUCTION.

The United States Department of Agriculture estimates that the honey crop for 1918 will approximate two hundred and fifty million pounds. When it is recalled that the nectar in flowers does not become honey until it is worked over and partly evaporated by the bees, the magnitude of the labor in which they engage is apparent. These industrious insects must move fully 150,000 tons of material during the season in making the honey crop, to say nothing of the honey consumed by the bees themselves. The labor seems out of all proportion to the insect. The best all-round honey plant is reported to be the white clover. About half the honey produced is gathered from this plant. Next in importance comes alfalfa, followed closely by sweet clover. In some regions the latter is the chief honey-producer. A good deal of honey is gathered from the general run of flowers, but the plants that produce a honey that can be identified are not many. The principal species are cotton, basswood, tulip tree, buckwheat, goldenrod, and mountain sage. In the tropics the logwood, one of the legumes, produces much honey. At present, California produces about one-fifth of the honey crop. Other honey-producing states, though far behind California, are New York, Texas, Michigan, Iowa, Colorado, Wisconsin, Missouri, and Pennsylvania. —[*American Botanist.*

ECHOES OF THE WAR IN GREENLAND.

The world at war is making itself felt even in the Smith Sound region. No supplies have reached the station at North Star Bay, and nearly all the ammunition is exhausted. The Eskimos will soon be forced to resort to the primitive methods of hunting and living that they employed before the white man came with his guns, ammunition, cooking utensils, knives, matches, tea, and cloth. In Danish Greenland, where the natives have become quite dependent on the simple provisions and equipment sold them by the Royal Trading Company, the effect is even more pronounced and prospects even darker, for there the people have quite forgotten the methods of hunting employed by their ancestors and have to rely in large measure upon imported supplies.

Last year the hunt was generally poor in the northern districts, with small kills of seal and white whale, the chief resources of the Greenlanders. The summer of 1917 was an unusually severe and unfavorable season, with much snow, cloudy weather, and cold. The winter began early. As far south as Umanak sledging was possible in mid-November, so that the Eskimos could go out to set their seal nets. Heavy ice came soon afterward and did not break up again. The governor and the doctor at Upernivik, while out on a motor-boat journey, were frozen in far from the village and did not escape to return to their homes until after a month's absence.—[*Geographical Review.*

PROPOSED AMENDMENT TO THE CONSTITUTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

It is proposed that Article IV of the Constitution be amended to read as follows:

This Association shall be divided into sections as follows: Biology, Chemistry, Earth Science, General Science, Mathematics and Astronomy and Physics.

THE THOMAS CHARLES COMPANY.

The writer of this paragraph has watched the development of this splendid company for the last thirty years with interest and pleasure. It surely is with much delight that the kindergarten world looks upon the remarkable success of this firm. They have been obliged to move their place of business several times during this period, on account of the need of more room in order to handle their ever-increasing business. They have recently moved to their new and commodious building at 2249-53 Calumet Ave., Chicago, Ill., where they will be pleased to see their friends at any time. The venerable Thomas Charles, a most remarkable gentleman with a mind as keen and active today as it was fifty years ago when he was in his young manhood, will be only too pleased to see any person who is connected with the schools in any way, shape, or manner. The genial and capable secretary and manager, William T. Dix, on whose shoulders the burden of the firm now rests, very largely, is a person who deserves all the success that has come to the company. This success is due not so much to the demand for kindergarten goods, as to the uprightness, honesty, and integrity of the firm in all its dealings. Their new building is four stories in height and has an area of 10,500 square feet on each floor. The firm is the northwestern representative of the Milton Bradley Company of Worcester, Mass. Do not hesitate to send them any order for kindergarten material. You will always be treated well.

INCREASE IN PRODUCTION OF MARL IN 1917.

The marl sold for agricultural use in the United States in 1917 amounted to 73,900 short tons, valued at $165,223, compared with 58,088 short tons, valued at $144,768, in 1916, an increase of 25 per cent in quantity and 13 per cent in value. The average price, however, unlike that of nearly all other commodities, decreased from $2.32 to $2.21 a ton.

Of the total output, 47,914 tons, valued at $112,075, or $2.35 a ton, was fresh-water marl, a calcareous ooze consisting mainly of an accumulation of small shells formed of carbonate of lime and of minute crystals deposited from the same material by the action of bacteria. This output came from nine companies—three in Virginia, two in California, and one each in New York, Pennsylvania, West Virginia, and Arkansas. The production in 1916 was 48,447 tons, valued at $126,345, or $2.60 per ton, and was made by seven companies—three in Virginia, and one in each of the other States named except West Virginia.

Marine marl, derived from fragments of marine shells, loose or partly consolidated, was produced by five companies in the Coastal Plain region of North Carolina and South Carolina, the output amounting to 25,986 tons, valued at $53,148, or $2.35 a ton, in 1917, compared with 9,641 tons, valued at $18,423, or $1.91 a ton, in 1916.

The above figures were compiled under the direction of G. F. Loughlin, United States Geological Survey, Department of the Interior, from reports of producers and in cooperation with the State Geological Surveys of New York, North Carolina, Pennsylvania and Virginia.

ARTICLES IN CURRENT PERIODICALS.

American Botanist, for August; *Joliet, Ill.; $1.25 per year, 35 cents a copy:* "A New Form of Prunella Vulgaris," J. C. Nelson; "The Barberry and the Wheat Rust," Willard N. Clute; "Blossoms by the Wayside in the Rockies," Blanche H. Soth.

Geographical Review, for September; *Broadway at 156th St., New York City; $5.00 per year, 50 cents a copy:* "The Finn in America" (five maps, thirteen photos), Eugene Van Cleef; "On 'Savssats': A Crowding of Arctic Animals at Holes in the Sea Ice" (one map, six photos), Morten P. Porsild; "The Galapagos Islands," George M. McBride; "The Real Temperatures Throughout North and South America" (one map, twenty-seven diagrams), Mark Jefferson; "The Slavs of Northern Hungary" (three insert maps in color, one text map, one diagram), B. C. Wallis.

Journal of Educational Psychology, for June; *Baltimore, Md.; $3.00 per year, 50 cents a copy:* "Monroe's Standardized Silent Reading Tests," Walter S. Monroe; "Psychological Aspects of Language," George C. Brandenburg; "An Absolute Point Scale for the Group Measurement of Intelligence. Part II," Arthur S. Otis.

Journal of Geography, for October; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Ways of Raising Geography Teaching Above the Commonplace," Ona I. Nolan; "Cities in Spain," Frederick Homburg; "The Reef-Encircled Islands of the Pacific (Continued)," W. M. Davis.

National Geographic Magazine, for July; *Washington, D. C.; $2.50 per year:* "New York—Metropolis of Mankind" (thirty-nine illustrations), William J. Showalter; "Under the Heel of the Turk" (fourteen illustrations), William H. Holt; "A Day in the Geographic Words" (eight illustrations), Carol Corey.

Photo Era, for September; *Boston, Mass.; $2.00 per year, 20 cents a copy:* "Camouflage-Effects—Their Relation to Photography," William S. Davis; "Price Hires a Model," Frank King; "Pictorial photography as I See It (In Three Parts—Part II)," C. W. Christiansen; "Are Lenses Fairly Marked?" R. Child Bayley; "Better Pictures for the Nature-Lover," Bertran F. Hawley; "Enter—Professor Pyro," Michael Gross.

Physical Review, for October; *Ithaca, New York; $6.00 per year, 60 cents a copy:* "On the Variations of the Photo-electric Current Due to Heating and the Occlusion and Emission of Gases," L. A. Welo; "Electric Force on the Mercury Arc," C. D. Child; "Effects of Dielectrics on the Sparking Voltage," E. R. Wolcott; "On the Effect of a Transverse Magnetic Field on the Discharge Through a Geissler Tube," James E. Ives; "The Diffraction of Light by an Obliquely Held Cylinder," T. K. Chinmayanandam; "The Effect of Gases and Metallic Vapors on the Electrical Properties Exhibited by Selenium Crystals of the Hexagonal System," W. E. Tisdale.

School Review, for September; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "Progressive Requirements in American History for Junior and Senior High Schools," Committee on History and Social Studies; "Supervised Study in the University of Chicago High School," G. L. Harris; "The Teaching of Civics," Charles H. Judd.

SCIENCE QUESTIONS.

Conducted by Franklin T. Jones.

The Warner & Swasey Company, Cleveland, Ohio.

Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, 10109 Wilbur Ave., S. E., Cleveland, Ohio.

Please send examination papers on any subject or from any source to the Editor of this department. *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal.*

Lists of questions are acknowledged from G. H. Stone, Lawrenceville, Ill. This contribution from Mr. Stone reminds the Editor that he has received very few questions from State Examining Boards. From each state will some *two or three* make themselves committees to forward such material?

Science Tests.

The Editor still promises further tests. Make suggestions.

Walter N. Lacy, Anglo-Chinese College, Foochow, China, sends in a partial report on physics tests.

G. H. Stone, Township High School, Lawrenceville, Ill., asks to be enrolled among those interested.

Tests on mechanics and on chemistry will soon be prepared and mailed to all who are on the list. Your assistance will be greatly appreciated.

QUESTIONS AND PROBLEMS FOR SOLUTION.

309. *Proposed by Franklin T. Jones.* (The readers of SCHOOL SCIENCE AND MATHEMATICS have ideas as to *Science in the High School of Tomorrow. Please send in these ideas as soon as you receive this journal.*)

(*a*) What should be the science in the high school of tomorrow?

(*b*) What immediate modifications of our science work should be introduced to meet the present emergency in education?

(*c*) Should these modifications become fixtures?

(*d*) What modifications have you already introduced?

Please answer very promptly.

The following questions are contributed by Mr. G. H. Stone, Lawrenceville, Township High School, Lawrenceville, Ill.

(Minnesota readers will please notice and send other lists to the Editor.)

MINNESOTA STATE HIGH SCHOOL BOARD.

May Examination of 1918.

Answer questions in the order given. Put down the number of the question and its credits whether you answer it or not. The time for writing this examination is two hours.

CHEMISTRY—MONDAY, MAY 27, 2 P. M.

(*Answer Any Five.*)

1. Laws. Give: (*a*) (5) the law of Charles; (*b*) (5) the Law of Definite Proportions; (*c*) (5) the Law of Multiple Proportions; (*d*) (5) Avogadro's Hypothesis.

2. Laboratory Preparations. Describe any two, giving equations: (*a*) (10) the preparation of carbon dioxide; (*b*) (10) the preparation of chlorine; (*c*) (10) the preparation of ammonia.

3. Formulas. Write the chemical formulas for any five of the following compounds: (*a*) (4) cane sugar; (*b*) (4) ethyl alcohol; (*c*) (4) saleratus; (*d*) (4) acetic acid; (*e*) (4) calcium carbonate; (*f*) (4) ammonium sulphate; (*g*) (4) acetylene.

4. Tests. Describe any two: (*a*) (10) a test for the presence of soluble chlorides; (*b*) (10) a test for the presence of soluble sulphates; (*c*) (10) Fehling's test for sugar.

5. Problems. Solve any two:

(*a*) (10) What is the percentage composition of potassium nitrate?

(*b*) (10) How much hydrogen by volume can be made from water and 100 grams of metallic sodium?

(*c*) (10) A gas measures 650 cc. at 755 mm. and 70° C. Find the volume at 760 mm. and 0° C.

6. War Chemistry.

(*a*) (12) Discuss the chemical composition of fats, sugar, lean meat, and war flour, and state for each how it helps to run the human mechanism.

(*b*) (6) What is the approximate chemical composition of smokeless powders and of trinitrotoluol?

(*c*) (2) Why do these compounds explode readily?

7. Chemical Terms. Define and illustrate five of the following:

(*a*) (4) synthesis; (*b*) (4) acid; (*c*) (4) salt; (*d*) (4) fermentation; (*e*) (4) atomic weight; (*f*) (4) valence.

8. Chemical changes. Describe, preferably with equations, what occurs chemically in four of the following: (*a*) (5) action of baking powder in cooking; (*b*) (5) lighting of a match; (*c*) (5) explosion of methane, CH_4, in coal mines; (*d*) (5) formation of starch in leaves of plants; (*e*) (5) blackening of silverware; (*f*) (5) setting of plaster of Paris.

PHYSICS—MONDAY, MAY 27, 2 P. M.

1. (20) Define or explain any five: (*a*) weight; (*b*) Northern lights; (*c*) astigmatism; (*d*) acceleration; (*e*) convection currents; (*f*) quality of sound; (*g*) electrolysis; (*h*) efficiency of a machine.

2. (20) State a practical application of the following laws: (*a*) Joule's Law for the quantity of heat developed in a conductor carrying a current of electricity; (*b*) Hooke's Law; (*c*) Law of Levers; (*d*) Law of Centrifugal Force.

3. (20) State in a sentence or two, the use you made of five of the following instruments in your laboratory: (*a*) tuning fork; (*b*) caliper; (*c*) galvanometer; (*d*) rheostat; (*e*) hydrometer; (*f*) calorimeter; (*g*) siphon; (*h*) induction coil.

4. (20) Give in detail how you worked out any two of the following problems in your laboratory: (*a*) specific heat of any metal; (*b*) electrical resistance of a coil of wire or of some instrument; (*c*) the magnifying power of a simple lens; (*d*) the verification of Boyle's Law; (*e*) the density of a solid lighter than water.

5. (20) Solve any two of the following:

(*a*) How many horsepower are there in a waterfall of 30 ft., if 1,000 cu. ft. of water pass over it in a minute?

(*b*) What is the power of a dynamo if it produces 20 amperes of current at 110 volts?

(*c*) Find the cost of running a washing machine of one-half horsepower motor for 3 hours, if the cost of electricity is 8 cents per K. W.

(*d*) What mass of water at boiling point will just melt 25 K. G. of ice at 0° C.?

(*e*) How far above the earth is an airplane from which a bomb is dropped, if the bomb strikes the earth in fifteen seconds?

6. (20) Explain any five of the following: (*a*) photography in the manufacture of expensive books; (*b*) why boys in playing prefer a steel ball as a "shooter"; (*c*) the effect of expansion and contraction in the deterioration of building structures; (*d*) the use of the hydraulic ram on the farm; (*e*) air cushions in sudden water pressure changes; (*f*) what simple machine you are making use of in sweeping with a broom; (*g*) the occurrence of osmotic pressure in nature; (*h*) why "hearing" is so easily injured in warfare; (*i*) why binoculars are in such demand at present.

PRODUCTION OF PLATINUM IN THE UNITED STATES IN 1917.

According to figures compiled by J. M. Hill, of the United States Geological Survey, Department of the Interior, only 605 ounces of crude platinum was sold by placer mines in 1917. This is less than the sales in 1916 by about 100 ounces. The imports of crude platinum amounted to 31,921 ounces, not counting the 21,000 ounces of Russian crude platinum which was received by the Government late in December.

During 1917 refiners made about 33,000 ounces of platinum, 4,800 ounces of palladium, 833 ounces of osmiridium, and 210 ounces of iridium, which can be called "new metals." Of this amount about 7,400 ounces probably originated from domestic materials.

The saving of scrap platinum of all classes resulted in much larger recoveries of secondary platinum metals than in previous years, a total of 72,000 ounces being recovered, as compared with 48,000 ounces in 1916.

PROBLEM DEPARTMENT,

Conducted by J. O. Hassler.

Crane Technical High School and Junior College, Chicago.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions.*

We desire also to help those who have problems they cannot solve. *Such problems should be so indicated when sent to the Editor, and they will receive immediate attention. Remember that it takes several months for a problem to go through this department to a published solution.*

All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages. In selecting problems for solution we consider* accuracy, comp'eteness, *and* brevity *as essential.*

The Editor of this department desires to serve its readers by making it interesting and helpful to them. If you have any suggestion to make, mail it to the Editor. *Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

SOLUTION OF PROBLEMS.

Algebra.

566. *Proposed by R. T. McGregor, McArthur, Cal.*

Solve the equation

$$\sqrt[4]{x+27}+\sqrt[4]{55-x}=4.$$

I. *Solution by R. M. Mathews, Duluth, Minn.*

Put $u^4=x+27$, Then $55-x=82-u^4$

and the given equation becomes

$$\sqrt[4]{82-u^4}=4-u$$

$\therefore 82-u^4=256-256u+96u^2-16u^3+u^4$

or $u^4-8u^3+48u^2-128u+87=0$.

The roots of this equation are

$$u = 1,\ 3,\ 2+5i,\ 2-5i.$$

whence $x = -26,\ 54,\ 14-840i,\ 14+840i$.

Each of these roots checks.

II. *Solution by Nelson L. Roray, Metuchen, N. J.*

$$\sqrt[4]{x+27}+\sqrt[4]{55-x}=4$$

Raising to 4th power and factoring we have

$(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}[2((27+x)^{\frac{1}{4}}+(55-x)^{\frac{1}{4}})^2-(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}]=87$

or $(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}-32(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}+87=0$

$[(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}-3][(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}-29]=0$

$(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}-3=0$ and $(27+x)^{\frac{1}{4}}(55-x)^{\frac{1}{4}}-29=0$

whence $x^2-28x-1404=0$ and $x^2-28x+705796=0$

and $x = 54$ or -26 and $x = 14\pm840i$.

The roots of $x^2-28x+705796=0$ are redundant.

III. *Solution by Philomathe, Montreal, Can.*

Let $\sqrt[4]{x+27}=y$ and $\sqrt[4]{55-x}=z$.

Then we have the system: $y+z = 4$ (1), $y^4+z^4 = 82$ (2),
square (1), $y^2+z^2+2yz = 16$ or $y^2+z^2 = 16-2yz$ (3),
square (3), $y^4+z^4+2y^2z^2 = (16-2yz)^2$ (4),
(2) and (4) give $82+2y^2z^2 = (16-2yz)^2$ (5),
(5) is a quadratic equation in yz. Its roots are 3 and 29;
The system $y+z = 4$ and $yz = 3$ gives $y = 3$, $z = 1$, hence $x = 54$, or $y = 1$, $z = 3$, hence $x = -26$;
The system $y+z = 4$ and $yz = 29$ gives imaginary roots.

These roots are $y = 2\pm5i$ and $z = 2\mp5i$;
for $y = 2+5i$, $x = (2+5i)^4-27 = 14(1-60i)$,
for $y = 2-5i$, $x = (2-5i)^4-27 = 14(1+60i)$.

The roots are 54, -26 and $14(1\pm60i)$.

Solutions were also received from NELLIE F. HENDERSON *and* ROXANNA E. SPILLER.

Geometry.

567. *Proposed by N. P. Pandya, Sojitra, India.*

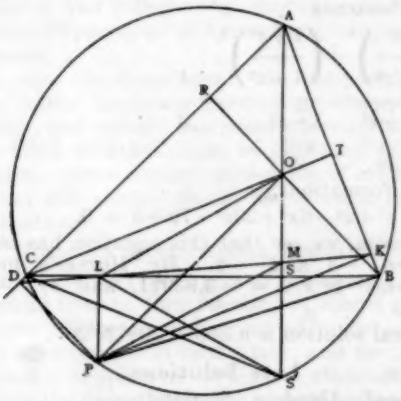
Circumscribe a triangle about a given circle, the ratio of the angle bisectors being known.

A note on this will be published in the next issue.—*Editor.*

568. *Proposed by Murray J. Leventhal, Stuyvesant High School, New York City.*

The line that joins the orthocenter of a triangle to any point on the circumscribed circle bisects the line joining the feet of the perpendiculars dropped from this point upon the three sides of the triangle.

Solution by Nelson L. Roray, Metuchen, N. J.



Let ABC be the given triangle, O the ortho-center, P any point on the circumcircle, PD $\perp$AC, PL $\perp$CB, PK $\perp$AB, AS $\perp$CB, BR $\perp$AC, CT $\perp$AB, S′ point on circle where AS intersects circumference, DLK Simson's Line intersecting AS at M.

Then OS = SS′
also P, L, K and B are concyclic
$\therefore \angle PKL = \angle PBL = \angle CS'P$
$\angle SMK = 360-(180+\angle PKL+\angle SBA)$
$= 180-(\angle PKL+\angle SBA)$
and $\angle SML = \angle PKL+\angle SBA = \angle PS'A$.
$\therefore$ PLMS′ is an isosceles trapezoid.

and PM = $\angle S' = \angle O$

$\therefore \angle COL = \angle CS'L$ ($\triangle COL \cong \triangle CS'L$)

$\therefore \angle MOL = \angle PMS' = \angle MS'L$

and LO || PM

and PO is bisected by DLK.

Note: PO does not bisect Simson's Line nor can it, since the line is a straight. PO bisects certain parts of it, e. g., LM in the above.

Also solved by Philomathe.

569. *Proposed by N. P. Pandya.*

The vertex A of a triangle is the center of a given circle. P and Q are points of intersection of AB, AC, respectively, with the circle. The tangents at P and Q divide the base in the ratios $k : l$ and $m : n$, respectively. Construct the triangle ABC.

No solutions of this problem have been received. The editor will consider it in the next issue.—*Editor.*

Trigonometry.

570. *Proposed by R. T. McGregor.*

Find θ when

$$\frac{\tan^3\theta+\sec^3\theta}{\csc\theta-\operatorname{ctn}\theta} = \frac{1}{3}.$$

Solution by Philomathe, Montreal, Can.

Let $\tan\frac{\theta}{2} = x$, then $\sin\theta = \frac{2x}{1+x^2}$ and $\cos\theta = \frac{1-x^2}{1+x^2}$,

the given equation becomes

$$\frac{\left(\frac{2x}{1-x^2}\right)^3+\left(\frac{1+x^2}{1-x^2}\right)^3}{\frac{1+x^2}{2x}-\frac{1-x^2}{2x}} = \frac{1}{3},$$

or, after a few transformations,

$$x^6+x^4-6x^3+20x^2-7x+3 = 0.$$

By Sturm's theorem, we see that this equation has but one real root, and it is between -3 and -4. By Horner's method, I found $x = -3.93911$, hence $\operatorname{tg}\theta/2 = -3.93911$, and $\theta/2 = 104°14'40''$, or $\theta = 208°29'20''$.

Note. The general solution is $n.360° + 208°29'20''$.

Late Solutions.

558. *Angus McLeod, Aberdeen, Scotland.*

Answers to Queries.

Concerning certain objections to proofs of problem 554, which was published in May, the editor wishes to say that although solutions II and III are not worked out in detail, to save space, it is true that when the proper algebraic reductions are performed the result may be stated in a manner similar to that used in solution VI at the close. The solver of III suggests that $(a^2+b^2-c^2)/2ab$ be substituted for cosC in performing the reduction. *It must be remembered that a, b, and c are positive values by the nature of the problem.*

PROBLEMS FOR SOLUTION.

581. *Proposed by A. MacLeod, Aberdeen, Scotland.*

The six straight lines which trisect the angles of a triangle meet in three points which form the vertices of an equilateral triangle.

Could four equilateral triangles be found determined by the twelve interior intersection points of these six lines?—*Editor.*

582. *Proposed by A. MacLeod.*

A and B are two points outside a circle unequally distant from the center. Find the point C on the circle such that AC+CB is a minimum.

583. *Proposed by Norman Anning, France.*

Solve the triangle, $a = 181$, $A = 120°$, $b-c = 1$.

584. *Proposed by Norman Anning.*

AD, BE and CF are the medians of the triangle ABC; show that $\cot ADB+\cot BEC+\cot CFA = 0$.

585. *Proposed by Norman Anning.*

Eliminate θ from the equations

$$x = \cos 2\theta+2\cos\theta,$$
$$y = \sin 2\theta-2\sin\theta.$$

BIRDS HELP SCHOOL GROUNDS.

HOW AND WHY THEY SHOULD BE ATTRACTED TO THE YARD OR CAMPUS.

Birds have such an important part in the courses of nature study given in most schools and colleges that more should be done, according to the United States Department of Agriculture, to attract them to school grounds or campuses.

Unfortunately, says the department, the campus, like the park, has suffered from too formal landscape gardening. Cropped hedges are not inviting to the birds, and wooded campuses where formerly birds abounded have been so filled with buildings, so gardened and formalized that birds are now scarce. Some corner—preferably of original woodland and undergrowth if that still exists—should be set aside and allowed to run wild, as a bird sanctuary.

BIRDS AN EDUCATIONAL RESOURCE.

In addition to the help that birds give as protectors of trees and shrubbery against injurious insects, they furnish, on school grounds, a distinct educational resource. There is scarcely an advanced school in the country that does not offer courses in bird study; and the study of birds out of doors is a necessary supplement to that in classroom and laboratory. For this reason, says the department, the educational need should be kept in view by those in charge of college and school grounds.

Plants which furnish bird foods should be added, nest boxes put up, and winter feeding carried on as an interesting and instructive part of the work in bird-study classes. It is further suggested that the teacher of ornithology should be called in to advise in relation to the planning and treatment of the campus.

Those who are interested in attracting birds to public and semipublic reservations can get a publication devoted to this subject by writing to the United States Department of Agriculture at Washington for Bulletin 715.

BOOKS RECEIVED.

Census of the Virgin Islands of the United States, by Eugene F. Hartley. 174 pages. 15x23 cm. Paper. 1918. Government Printing Office.

Airplane Characteristics, by Frederick Bell, Cornell University. Pages v+123. 16x23 cm. Cloth. 1918. $1.60 net. Taylor & Company, Ithaca, N w York.

Petroleum; A Resource Interpretation, by Chester G. Gilbert and Joseph E. Pogue, United States National Museum. 81 pages. 15.5x24.5 cm. Paper. 1918. Government Printing Office.

Ontario High School Laboratory Manual in Chemistry, by George A. Cornish, University of Toronto, and Arthur Smith, Central Technical School, Toronto. Pages vii+135. 12.5x19 cm. Cloth. 1917. 25 cents. The Macmillan Company, Toronto.

Ontario High School Chemistry, by George A. Cornish, University of Toronto, and Arthur Smith, Central Technical School, Toronto. Pages vii+297. 12x19.5 cm. Cloth. 1918. 50 cents. The Macmillan Company, Toronto.

Essentials of Modern Chemistry, by Charles E. Dull, South Side High School, Newark, New Jersey. Pages ix+458. 13.5x19.5 cm. Cloth. 1918. Henry Holt & Company, New York City.

General Science Manual, by Leland R. Thompson, High School, East Chicago, Ind. Loose-leaf. 101 experiments. 21x27 cm. Atkinson, Metzger & Company, Chicago.

BOOK REVIEWS.

General Science Manual, by Leland R. Thompson, High School, East Chicago, Ind. Loose-leaf. 101 experiments. 21x27 cm. Atkinson, Metzger & Company, Chicago.

A splendid, practical, and up-to-date manual on general science. A book that can work into almost any laboratory and be used with any text on this subject. It deserves a wide and extensive sale. C. H. S.

Economy in Food, by Mabel T. Wellman, Indiana University. 36 pages. 13x19 cm. Cloth. 1918. 30 cents net. Little, Brown & Company, Boston.

A remarkable little book which ought to be in the possession of every housekeeper and person who buys food for the family or restaurant. In a small space rules and advice are given on economy in buying, economy in storing food, economy in planning meals, economy in the use of left-overs, and economy in fuel. There is a splendid table of cost of one hundred calorie portions of foods and factors for calculating them.

C. H. S.

Second Course in Algebra, by Herbert E. Hawkes, Colorado University, William E. Lobe, Kansas City Polytechnic High School, and Frank C. Touton, Central High School, St. Joseph, Mo. Pages vii+277. 13x19 cm. Cloth. 1918. $1.00. Ginn & Company, Boston.

This is a revision of a well-known and widely circulated text. It has been considerably simplified, and some chapters have been omitted in accordance with the present tendencies to dismiss from school courses those that are nonessential. In the place of these omitted chapters the emphasis is put on the material which is of everyday and lasting importance. The exercises, of which there are a large number, are practically new, and many of them are for oral use. Instructors will find this as nearly perfect a text in algebra as it is possible to produce. C. H. S.

Elementary General Science, by Daniel R. Hodgdon, Normal School, Newark, N. J. Pages xxii+553. 15x20.5 cm. Cloth. 1918. Hinds, Hayden & Eldredge, New York City.

This remarkable book has been written for use in the seventh and eighth

grades and the first years of the junior high school. It is one of the very latest books on general science, and without question is one of the best texts lately put on the market in this subject. The volume is written in a most fascinating style, and in such a manner as will appeal to the interests of the young mind. The author has distributed the amount of matter over the various sciences that are discussed, very uniformly, giving each science, as he understands it, its fair proportion of space. He has made good use of books and matter bearing upon the subjects treated in the text, and has given due credit. He is very wise in the selection of the 395 cuts and illustrations, many of which are new and to the point. The chapter on "Nostrums" is peculiarly apropos. Too much cannot be said in praise of the volume, and it undoubtedly will receive a very large adoption. C. H. S.

The Organization of Thought, by A. N. Whitehead, Trinity College, Cambridge. Pages vii+228. 14.5x22.5 cm. Cloth. 1917. $2.00. J. P. Lippincott Company, Philadelphia.

This volume is a compilation of discourses which were delivered by the author on various occasions. The book treats of the idea of thought as presented in the eight addresses included in the book. A common l ne of thought or reflection extends through the book. The fact that the discourses are given in an informal way makes it of a more practical value to the everyday reader than if the talks were of a more technical nature. The author is well informed on the results of the events that are now transpiring in Central Europe, and he has brought his thought into connection with the general reformation of all activities which must necessarily follow the conclusion of this great war. From cover to cover there are many suggestions that will meet the approval of the reader. The book is mechanically well made, and is printed on thick, uncalendered paper, in heavy, doubl spaced type, making it very easy to read. The volume should have a wide circulation. C. H. S.

Elements of General Science, Revised Edition, by Otis W. Caldwell, Teachers College, Columbia University, and William L. Eikenberry, University of Kansas. Pages xii+404. 13.5x20 cm. Cloth. 1918. Ginn & Company, Chicago.

This revised edition of a splendid book has been brought up to date, and in this treatment of the various subjects the authors have, if possible, improved upon the excellent first edition. There is nothing of a detrimental nature that can be said concerning this most excellent book. It is the result of many years' experience in the instruction of secondary pupils by these two most competent authors, and that which they present in this volume is authoritative, accurate, and to the point. The 181 cuts and illustrations have been selected with a view to illustrating directly the material treated in the text. The authors' study of the general science situation of the United States has been of such a character that they have been able to produce a book which can be used without any difficulty in any part of the country. Doubtless the new edition will have as wonderful a sale as the first edition had. School men will make no mistake in adopting this book for their classes. C. H. S.

Essentials of Physics for College Students, by Daniel W. Hering, New York University. Pages x+367+31. 15x22.5 cm. Cloth. 1914. $1.75 net. D. Van Nostrand Company, New York City.

This is the second edition of this most excellent text in physics, and is the outgrowth of a series of lectures which the author delivered before the undergraduate students of New York University. There are a number of changes made in this edition over the first one, and in every case the change has been for the better. It has been the object of the author to produce a book in reasonably complete form, so that the ordinary man

may be able to secure technical knowledge of physics without becoming an expert engineer. Some of the cuts might have been improved upon, but this fact does not in any way injure the nature of the text. The book consists of seven chapters, the major paragraphs of which begin with bold faced type. At the close of each chapter there are many experiments given which are discussed in the body of the chapter. There are several tables of physical constants appended. There is a splendid index of seven double column pages. The volume is worthy to be in the library of every physicist and technical man. C. H. S.

Airplane Characteristics, by Frederick Bell, Cornell University. v+123 pages. 16x23 cm. Cloth. 1918. $1.60 net. Taylor & Company, Ithaca, New York.

Whenever anything new appears in science, or whenever a change in the world's history is brought about, books are bound to appear discussing this phase of progress. This is one of the first books that have been produced on aeronautic which it is possible for the ordinary layman to read and understand, for an extended knowledge of mathematics is not necessary to the reader. The volume is written by a past master in the theory of airplane characteristics. The author has produced a book from his fund of knowledge which is second to none in excellence. The cuts and diagrams are selected to show just what the author discusses. It is a text that ought to be familiar to every person in this country who is in any way connected with the aviation corps of the United States Government. There are four appendices, the first being a complete glossary of terms used in aviation. The others are of a more technical nature. Physics teachers in schools and colleges should send for a copy of the book. C. H. S.

The Vocational Education of Girls and Women, by Albert H. Leake, Inspector of Manual Training and Household Arts, Ontario, Canada. Pages xix+430. 13x19.5 cm. Cloth. 1918. $1.60. The Macmillan Company, New York City.

This book has been prepared in a great measure for the large number of instructors who are engaged in the teaching of our pupils in the lower schools. It is intended likewise to appeal to students in normal schools and colleges who are preparing themselves to become teachers of vocational instruction of girls and women. The author does not attempt to discuss any detail of industrial occupation which is not open to women, but he bears down heavily on the way in which girls and women should be instructed in order to be able to earn a livelihood in any vocations which they may feel themselves competent to follow. The book is the result of many years' experience in practical manual training, household science, and industrial education in general. There are fourteen chapters, each of which is divided into many important topics. The major paragraphs have the subject of the discussion printed in bold faced type. The volume is interesting to read, not only for the teacher but for the ordinary lay-woman. It is printed in 10 point type, on uncalendered paper, thus reducing the glare of reflection to a minimum. The half tone illustrations have been selected with care. There is a bibliography appended, and there is also a complete double column index of ten pages. The book deserves a wide circulation. C. H. S.

Mammalian Anatomy, with special reference to the Cat, by Alvin Davison. Ph. D., third edition, revised by Frank A. Stromsten, D. Sc. 115 illustrations. 243 pages. 14×20 cm. P. Blakiston's Son & Co. $2.00 net.

As indicated above, this is a revised edition of a standard work. The

authors say with truth that "the great value of this manual has been its usable size and its concise elementary nature." They might have added that it is well and clearly written and planned and copiously illustrated. The title gives a correct idea of its scope. A good book.

W. W.

Principles of Economic Zoology, by L. S. and M. C. Daugherty. Second edition revised. 301 illustrations. 428 pages. 14×20 cm. W. B. Saunders Company. $2.00 net.

The first edition was reviewed in the columns of this magazine on its first appearance. As this edition has made few changes, it will not be necessary to go into details. The writer of this review could never understand why the title "Economic Zoology" was given to the book, for there is certainly no great amount of economic matter in the book. It seems to us that the natural history of animals, however, is an especially strong feature of the book. For schools which need this side of the work, as, perhaps, state normal schools, this book should present a strong appeal. It is a good book of its type and useful as a reference book in the high school classroom as well as a text for certain types of schools.

W. W.

Agricultural Bacteriology, by H. W. Conn, Ph. D., third edition revised by Harold Joel Conn. 63 illustrations. 357 pages. 14×20 cm. $2.00 net. P. Blakiston's Son & Co.

Owing to the author's death the revision of this book has been undertaken by another to bring the work up to date with more recent discoveries, especially in the lines of soil bacteriology, control of milk supplies and plant diseases. Professor Conn's books are always well written and especially notable for their clearness of diction. These good qualities have been retained in the revision.

The book is divided into five parts and after two chapters of a general and introductory nature there follow chapters on "Bacteria in Soil and Water"; "Bacteria in Dairy Products"; "Relation of Microorganisms to Farm Products"; "Parasitic Bacteria" and an appendix of laboratory directions. The treatment is non-technical and the style so clear that these important topics may be read and assimilated by the practical worker as well as by college students for whom the book is written. It is impossible in a brief review to give an adequate idea of the many good features, but a few may be mentioned. Throughout the work, but more especially following the more scientific exposition of a topic, the practical farm aspects of the topic are brought out. Some of the more important topics treated are those of organisms of the soil and of milk and their various applications. Knowledge of soil life is of vast importance to agriculture, and its importance can hardly be overestimated. Books which put this knowledge in form for wider circulation are especially valuable.

W. W.

Exercise and Review Book in Biology—New World Science Series, by J. G. Blaisdell, Yonkers High School. 152 pages. 20×26 cm. 21 illustrations. 80c. World Book Company.

This book is planned by the author to be a "laboratory guide, a notebook and a review book" for student use in the high school. The guide consists of directions for performing the experiment or other work of the lesson, followed by questions for observations and conclusions. All questions are followed by blank lines for an answer. Occasionally there are blanks for drawings, while at other times the drawings are already made for the pupil with letters for labelling the parts. The teacher supplies the material, the pupils answer the questions, doing whatever obser-

vation or thought work the questions require. The course included is fairly comprehensive, covering plants, animals and human physiology. The book is written especially for New York schools.

Such a scheme may be the best that can be done for schools with poorly trained teachers and large classes, or where the teacher is burdened with too many subjects. However, it should be the last resort, for it is bound to kill initiative in both teacher and pupil. Any course in biology, while including the great fundamentals of the subject, should be made to fit the local environment of the school as well as adapted to the pupils, the equipment and the teacher himself. Stereotyped sets of questions must inevitably lead to formality and stiffness in the course unless the teacher is unusually resourceful.

W. W.

The Teaching of Agriculture, by Aretas W. Nolan, University of Illinois. 277 pages. 12×19 cm. $1.30. Houghton Mifflin Company.

Agriculture, as a part of the curriculum of high schools, is a very new subject. Like all new subjects, its teaching methods are somewhat unorganized. It takes many years to standardize the methods of teaching a subject so that the best results may be obtained. However, agriculture is making rapid progress toward better and more systematic methods. This progress is helped along in this case by the very many excellent texts that have come off the press in the last year or two. But textbooks are not all that is needed, for each book covers only a portion of the field. We needed something that would give a broader outlook and the proper proportions and setting of each branch of the subject.

This organization of the field Professor Nolan has attempted in his "Teaching of Agriculture." It will not only be a source book of suggestions for the courses in agriculture but it is to be hoped it may aid in a better organization of the courses of study offered. There has been much perfunctory and consequently poor work in the teaching of agriculture, due to lack of standardization. There being no standard of attainment teachers, often overloaded with several subjects, have been tempted to be content with a very inadequate output.

Of course, no sensible teacher will think of attempting to use the outlines the book offers bodily without change. Courses of study and the curriculum itself should be adapted to and built to suit the needs of that particular school and neighborhood. The book contains a great abundance of outlines of courses, suggestions, data and various other helps for the teacher. The advice for the teacher appears always sound and well taken. We trust that every teacher of agriculture may have opportunity to read and use the book.

W. W.

DIRECTORY OF SCIENCE AND MATHEMATICS SOCIETIES.

Under this heading are published in the March, June, and October issues of this Journal the names and officers of such societies as furnish us this information. We ask members to keep us informed as to any change in the officiary of their society. Names are dropped when they become one year old.

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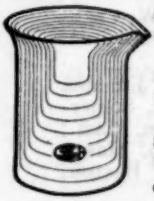

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RADIUM LUMINOUS COMPOUNDS.

The use of radium luminous compounds has only recently been recognized in connection with commercial apparatus, but is now widely known through the enormous sale of watches and clocks with "radium dials." It was as recent as 1910 that Marsden made the first measurements of the brilliancy of zinc sulphide under the action of the radiations from radium products, but it was not until several years later that advantage was taken of this fact to make instruments, which must be read at night, self-luminous.

Radium luminous compounds consist almost exclusively of specially prepared zinc sulphide, with which is mixed about four parts per 10,000 of radium bromide or its equivalent in gamma ray activity. To apply the paint, in practice, the powdered material is mixed with a minimum possible quantity of varnish or other suitable binding material, and laid on either with a brush or by filling in the figuring which has been engraved into the surface of the object to be painted. The luminosity of the material is due to the action of α = particles from the radium impinging on the crystals of zinc sulphide. The light is of a decidedly greenish hue and in the visible region lies between $\lambda = 5{,}920$ and $\lambda = 4{,}250$, with a fairly sharp edge toward the red. The degree of brightness is of the order of 10 microcandles per square centimeter, or .03 equivalent foot-candles.[1] This is about one-hundredth of the brightness of a newspaper satisfactorily illuminated for comfortable reading by artificial light. It is of the order of the brightness of white paper illuminated by the light of the full moon.

The luminosity of radium compounds falls off with time. The radium itself decays to half its value in about 2,000 years, and it has sometimes been assumed that radium paint will retain its luminosity for a similar period. But this is not the case, for decay is mainly due to action on the zinc sulphide itself, which loses its power to luminesce in the course of time. In general, the material attains a maximum brightness in ten to twenty days after mixing. The intensity then falls off gradually and probably becomes almost constant after a couple of years. Thus we may conclude that a watch dial which is satisfactorily brilliant after a year or two will continue to remain so.

When the material is applied as paint the rate of decay of luminosity is noticeably lower than that of the compound before application, and the initial luminosity is also smaller, being of the order of one-third to one-fourth of that of the compound before application. The reason for this is not clear, but it seems reasonable to suppose that the effect of the varnish or other medium is to impede the activity of the α = ray bombardment from the radium, and in this way cause an effective lowering of the radium content of the compound with a subsequent reduction of both the initial luminosity and also the rate of decay.

The initial brightness is in the ratio of the radium content, but the rate of decay of the compound of smaller content is slower, so that the ratio of the luminosities gradually approaches unity as time goes on. This question is of considerable commercial importance, for it is clear that if the compound is required for use after the lapse of several years, there is very little advantage, except from the point of view of initial brightness, in increasing the radium content beyond a certain point. For painted dials the maximum useful content for a life of over six months will not be more than .6 mg. per gram, and the minimum useful content about .2 mg. per gram. The factor of cost cannot be ignored for a compound containing .4 mg. of radium per gram of zinc sulphide costs about $30 to $35 per gram. This is mainly due to the amount of radium present.

[1] This unit is the brightness of a perfectly diffusing surface with a coefficient of reflection of 100 per cent when illuminated to an intensity of a one foot candle, i.e., by a source of one candle placed one foot away.